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THE SURGERY OF THE THYMUS GLAND*

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THE thymus gland seems to have been unknown to Hippocrates and Aristotle, and was first mentioned by Rufus the Ephesian in his enumeration of the discoveries in anatomy made at the School of Alexandria under the Ptolomies. It was Galen who first assigned to the thymus its supposed mechanical function of supporting the vena cava and its tributaries, and of protecting it from contact with the sternum. This belief held the field for many centuries, being repeated in the sixteenth century by Vesalius and his successors. In the seventeenth century the structure and anatomy of the thymus were to some extent elucidated, and Glisson first suggested that its activities might be in some way connected with the growth of the fœtus. This was repeated by Sir Astley Cooper in his monograph on the thymus in 1832, and he was the forerunner of a host of investigators who, in more recent times, have endeavoured without success to demonstrate some active principle or hormone in the thymus related to growth. It was again Sir Astley Cooper who drew attention to the fact that the thymus often became enlarged in association with what we now call toxic goitre, but again this clue failed to lead to any proof that the thymus had a definite function in relation to other endocrine organs such as the thyroid. It seems, therefore, that if the thymus gland is indeed a member of the endocrine orchestra, its notes are so muffled that no one, even of the most able investigators, has been able to distinguish them. Along with this empty record of achievement in elucidating the function of the thymus, we may note an almost equal absence of surgical interest. To illustrate this there is the fact that in the whole range of the *British Journal of Surgery* from its beginning in 1913 to the present time not a single contribution has been made on the surgery of the thymus, although this journal covers the most progressive period in the long history of surgical science. It might appear, therefore, that the surgery of this organ is a somewhat barren subject, but, in fact, there is now something of interest to communicate in an account of a contribution which surgery has been able to make during the last four years towards an understanding of the pathology, if not of the physiology, of the thymus gland. It is a good example of what Lord Moynihan used to call "the pathology of the living", when he wished to emphasize the inportance of surgery in advancing our knowledge of disease in the human body.

EMBRYOLOGY

It is obvious that the embryology of any ductless gland may have an important bearing on its ultimate function, and it is therefore desirable to know with accuracy the origin of the various constituents of the thymus. Many studies of this have been made, but the most satisfying and convincing account was that published by E. H. Norris in 1938. This investigator states that the thymus is derived from

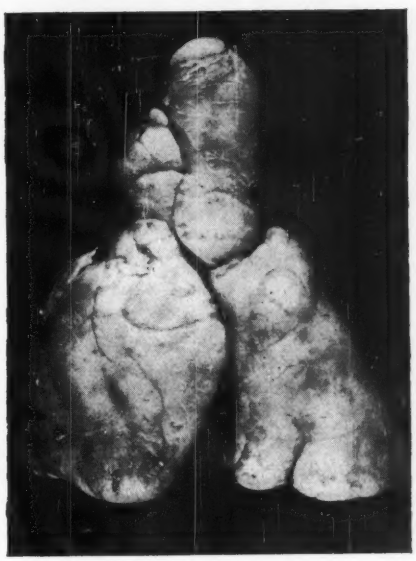


FIG. 238.—The thymus in the human fœtus.

the third branchial complex, that is, from both the endodermal pouch and the corresponding ectodermal sinus in the embryo. He finds that the third cervical sinus is the primordium of the primitive thymic cortex, and the source of the Hassall's corpuscles, which are the most conspicuous epithelial constituent of the fully formed gland. The epithelium of the endodermal pouch gives rise to the syncytial cytoreticulum of the gland, the cells of which are much less conspicuous than the Hassall's corpuscles in the normal gland. The bulk of the gland consists

* A Hunterian Lecture delivered at the Royal College of Surgeons, June 13, 1945.

of the thymic lymphocytes. These are of mesenchymal origin, and secondarily invade the gland after it has been entered by blood-vessels and connective-tissue cells. Lastly, the fibrous reticulum or framework is not derived from the epithelial elements, but from the connective-tissue cells in the adventitia of blood-vessels and in the capsule. Norris does not find that any part of the thymus comes from the fourth cervical sinus of the embryo, though other observers, notably J. R. Gilmour (1937), believe that a variable portion is derived from this source, this portion sometimes being situated in the neck in relation to the thyroid gland.

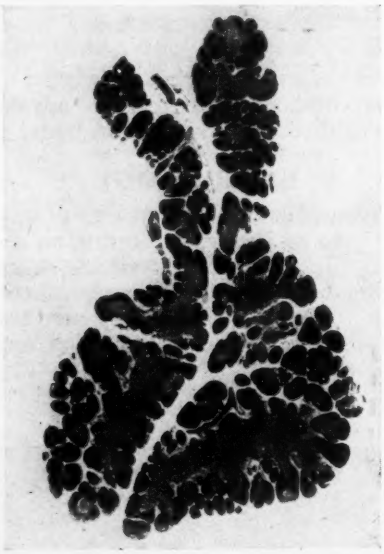


FIG. 239.—Stained section through the human thymus.

When the human fœtus is born the thymus is a relatively large structure which seems to occupy a considerable proportion of the upper thorax. It is shaped more or less as in *Fig.* 238. As it is composed of a number of separate lobules, a section through its mass, when suitably stained, presents the appearance seen in *Fig.* 239.

COMPARATIVE ANATOMY

It is impossible to believe that this large and complicated structure possesses no function in the animal economy. Its presence is not peculiar to man, and I have the authority of Professor F. J. Cole, Emeritus Professor of Comparative Anatomy at Reading University, for the statement that a thymus is found in all chordate animals. That is to say, it is represented in whales, elephants, mice, and all other mammals, in birds, in reptiles, and in all true fishes. It is even said to have been identified in amphioxus, the most primitive chordate of all. In one fish the developing thymus has ducts connecting it with the pharynx, presumably persistence of the endodermal pouch already mentioned, but these disappear during development. In all fully developed animals it is a ductless gland. It is usually larger in young animals than in old, but it certainly does not disappear in adult human beings, as has often been believed. This will be referred to again later.

SURGERY OF THE THYMUS

The paucity of surgical references to the thymus in the literature of this country has already been mentioned. It has, nevertheless, attracted the attention of surgeons in other countries, particularly in France.

THYMIC ASTHMA

There is a well-known condition sometimes seen in young children known as 'thymic asthma', in which there is a recurrent difficulty in breathing associated with stridor and cyanosis. Death sometimes ensues. This has been supposed to be due to the pressure in the thorax of an abnormally large thymus, and attempts have therefore been made to relieve the supposed obstruction to respiration by removing the thymus. A French surgeon, M. Victor Veau (1924), reporting to the Sixth Congress of the International Surgical Society in 1923, stated that three operations had been tried: (1) Exothymopexy, or fixation of the gland in the substernal space; (2) Resection of the manubrium sterni to relieve pressure: (3) Thymectomy. M. Veau claimed a considerable measure of success for the operation of thymectomy, which was performed through the neck. First, an incision was made above the suprasternal notch (*Fig.* 240). Secondly,

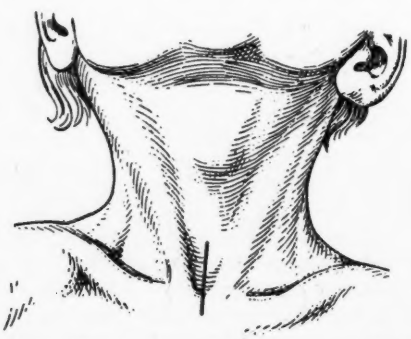


FIG. 240.—Thymectomy, first stage: the incision. (*After Veau.*)

the soft tissues were dissected down to the thymus (*Fig.* 241). Thirdly, the capsule of the gland was seized, and part of the gland dragged up through the opening (*Fig.* 242). It was always a partial resection, since the lower part of the gland could not be reached. None of the children operated on had died on the operating table, but 30 per cent of them were dead from various causes, such as infections or bronchopneumonia, within a month of the operation. It was claimed, however, that in four-fifths of the operated children the attacks of suffocation ceased, and stridor was less. In 1910 M. Veau had proclaimed: *c'était l'âge d'or de la chirurgie thymique*, but this golden age was short-lived. Medical opinion has fluctuated as to whether the thymus gland is really the cause of thymic asthma, and it is no longer generally believed that the thymus is the cause of death in the so-called "status lymphaticus".* But apart from this there was another good reason why

* This much debated question was settled in the negative by Young and Turnbull in 1931, working for the Status Lymphaticus Investigation Committee.

surgery for this condition has faded out and has not been heard of for many years.

An enlarged thymus gland can be demonstrated in infants by X-ray photographs because of its relatively large size, as is seen in *Fig.* 243, A. But,

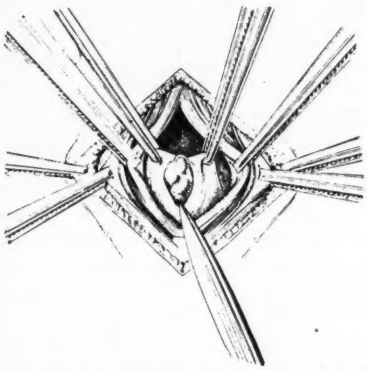


FIG. 241.—Thymectomy, second stage: dissection of the soft tissues. (*After Veau.*)

consisting largely of lymphoid cells, it can be made to disappear rapidly under X-ray irradiation. *Fig.* 243, B shows the effect of irradiation on the thymus seen in *Fig.* 243, A (Dr. Ralph Phillips)—a sufficient demonstration of why surgical treatment has ceased to be practised.

None of these would have been amenable to surgical removal, though the 14 tumours called lymphosarcoma and Hodgkin's disease could be temporarily improved by X-ray therapy. The removal of thymic tumours has, in fact, seldom been attempted, and most of those that have been removed were in patients who had myasthenia gravis associated with the

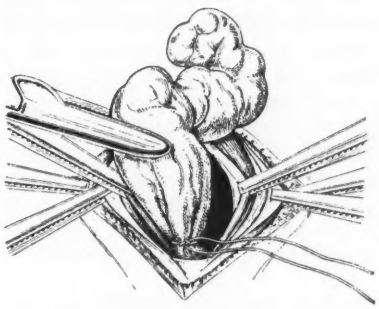
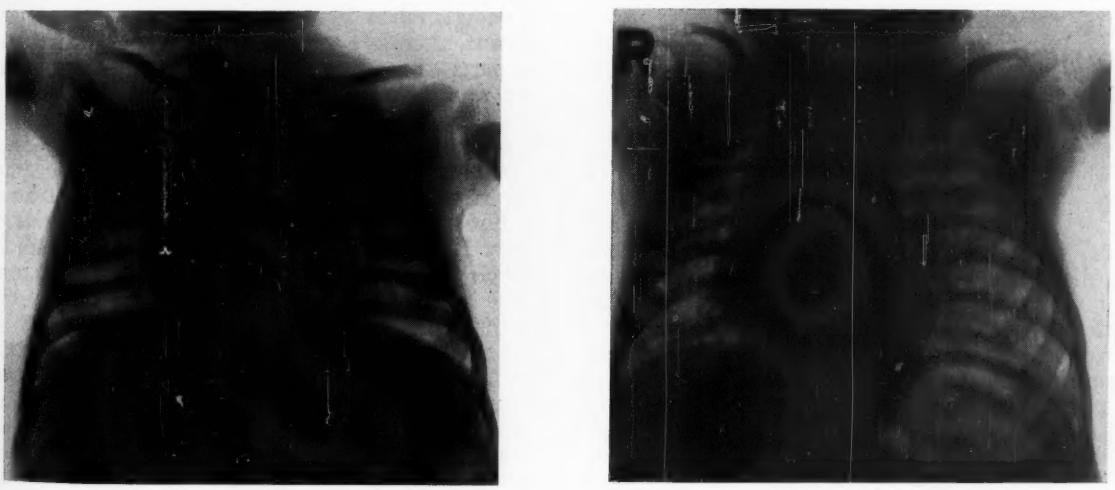


FIG. 242.—Thymectomy, third stage: exteriorization and ligature of the gland. (*After Veau.*)

growth. It seems that of the five kinds of thymic tumour just mentioned, the epithelial tumour is the only one that is ever found coexisting with myasthenia gravis, and furthermore, when the epithelial tumour does occur, the association with myasthenia is almost invariable.



A B

FIG. 243.—Radiographs showing the effect of irradiation of an enlarged thymus. A, Before irradiation; B, After irradiation.

THYMIC TUMOURS

The other possible application of surgery to the thymus was in the removal of tumours arising from the gland. Thymic tumours are, however, uncommon. A report on this point published in 1932 by Symmers (1932) records that among 17,000 post-mortem examinations performed at the Bellevue Hospital, New York, 24 thymic tumours were found. These were constituted as follows:—

Lymphosarcoma	9
Perithelioma	8
Hodgkin's' disease	5
Spindle-celled sarcoma	1
Epithelioma	1

The first recorded operation for benign thymic tumour with myasthenia was done by Blalock, of Baltimore, in 1936. This was successful, the patient being well four years later. Campbell reported two more such operations in 1941, one patient surviving with improvement. Two similar attempts which had been made in Germany by Sauerbruch, reported by Adler (1937) and Obiditsh (1937), resulted only in the death of the patients.

The mention of the epithelial tumours has thus introduced the disease known as myasthenia gravis, and at this point a digression must be made into the realms of medicine and physiology.

MYASTHENIA GRAVIS

Myasthenia gravis is reputed a rare disease, and many practitioners pass through the practice of a lifetime without ever having seen an example of it.

It is, however, probably not really so uncommon as is usually supposed. It is one of those chronic complaints of which little has been heard because treatment has been unsatisfactory, so that patients have been shelved as ones who could not be helped beyond a certain point. Patients of this type seem to accept their fate, and tend to be forgotten. Once some new and more effective treatment becomes established those forgotten ones that have survived begin to emerge from their hiding places, and a supposedly rare disease is found not to be so rare after all. This is already happening in relation to myasthenia gravis with the new hope afforded by the surgical treatment that has recently been practised.

Myasthenia gravis in its severer forms is a truly terrible disease. The extreme muscular weakness and a sense of hopelessness pervade the patient's mentality, and this makes worse the already melancholy aspect so often resulting from the fallen

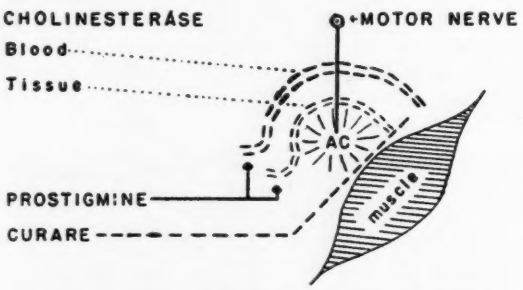


FIG. 244.—Diagrammatic representation of action of acetylcholine. (*After McEachern.*)

eyelids, the hanging jaw, the snarling expression when the patient tries to smile, and enfeebled limbs. In addition, the eyes move unequally, or even become completely immobile, and speech is reduced to a few imperfectly articulated words. Many patients cannot raise their food to their mouths, and when it is put there cannot chew it. Fluids are regurgitated through the nose, coughing is feeble and ineffective, and breathing is shallow. No wonder that the ultimate fate of these unfortunate people is so often a terminal infection of the lungs.

The clinical picture of myasthenia gravis presents endless variety, and is fascinating to study, but this is not a medical communication and it must not enter into too much clinical detail. Mention must be made, however, of the immense lightening of the burden that most of these patients have experienced since the introduction by Remen in 1932 of the drug prostigmine, its use in this country being due largely to the work of Dr. Margaret Walker (1934), of the L.C.C. Medical Service. Through its agency no patients have been cured, but the lives of many have been prolonged for years, and nearly all have been enabled to live at a higher level of activity for the time that they were spared. It is, of course, only with the help of prostigmine that any operation on these patients can be fairly safely performed.

This leads to a brief review of the theory of causation of myasthenia gravis, and *Fig.* 244, after McEachern (1943), presents the idea in a simple diagrammatic form. It is believed that the substance called acetylcholine is produced in the neighbourhood of the junction between the motor nerve-endings and the muscle-fibre. When the nerve is stimulated a minute quantity of acetylcholine is exploded, and this chemical change somehow activates the muscle. Limitation of its action is determined by the presence in both blood and tissues of another substance, cholinesterase, an enzyme which destroys excess of acetylcholine. The balance of these reactions results in normal action of voluntary muscle. The poison curare, which produces paralysis of voluntary muscles, is believed to act by interfering with the response of the muscle-fibre to the chemical stimulus. The state of the myasthenic patient is very much like curare poisoning, and the facts are best fitted by the supposition that the circulation of such an individual contains a substance which tends to inhibit the production or the action of acetylcholine. It has, in fact, recently been demonstrated by Wilson and Stoner (1944) at Sheffield that the serum of myasthenic patients does contain a substance which can be proved in the laboratory to interfere with transmission of an impulse in an ordinary muscle-nerve preparation. Another experiment done in Australia (Trethewie and Wright, 1944) has shown that myasthenic serum interferes with the production of acetylcholine by nerve-cells. In the myasthenic patient, therefore, muscular activity is enfeebled in all parts of the body, though why different muscles and muscle-groups should be affected so unequally and erratically as they are has not been explained. It appears, however, that myasthenia is not a disease of the nervous system, nor of the muscular system, but is a biochemical abnormality likely to depend on one of the endocrine organs of the body, since the effect is general, and its agent must be carried by the circulation of the blood. The action of prostigmine in alleviating the myasthenia is believed to be by inactivation of cholinesterase, so that acetylcholine can act in greater concentration on the muscle. It would not have been suggested that the thymus gland was to be incriminated as the source of the poison producing the disease, had it not been noticed many years ago that occasionally tumours of the thymus were associated with a myasthenic state, and it was presumably on this basis that, as long ago as 1912, Sauerbruch (Schumacher and Roth, 1913) attempted to remove the thymus gland from a myasthenic patient. The operation was done through the neck, and cannot have been complete, though the patient's condition was improved. The experiment was repeated by Haberer in 1917 and again the patient was improved, but nothing more was heard of the operation until 1941, when Blalock, of Baltimore, who, as mentioned, had already successfully removed a thymic tumour from a myasthenic patient, reported that he had tried the effect of deliberate removal of the thymus for myasthenia although there was no demonstrable tumour. But, unlike Sauerbruch, he realized that a total thymectomy could only be done by opening the mediastinum, so as to give a complete exposure

of the gland. This was a bold, but logical, step, and all honour is due to Blalock for having had the courage to do it. Having done the operation six times in 1941, beginning in July, he published a short report at the end of the same year, and the results he obtained were favourable enough for him to recommend a continued trial of the operation. In August, 1944, he reported on a series of twenty thymectomies, and his results continued to justify the procedure. Meanwhile, in February, 1942, Dr. Carmichael and Dr. James Carson, working at the National Hospital for Nervous Diseases, Queen Square, invited me to do the operation on a myasthenic patient under their care, since she was

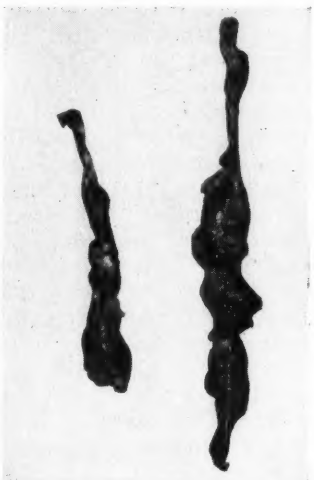


FIG. 245.—The first thymus gland removed.

obviously going to die very soon if the disease was left to take its course. This patient, a woman of 31, was bedridden and helpless in spite of large doses of prostigmine, and was clearly a very bad surgical risk, the more so as she had to be put in the hands of surgeons and nurses who were totally inexperienced in the management of myasthenic patients.

The thymus gland* (*Fig.* 245) was removed, and the patient, after a very rough passage, came safely through, and has, since that time, been able, with ups and downs, to lead a relatively active life, that is for over three and a half years. For a year after the operation she was, indeed, able to work for ten hours a day on the land. Beginning in February, 1942, I have performed the operation fifty-one times. Having had the good fortune to be associated for many years with Sir Thomas Dunhill and his work, I was accustomed to exploration of the mediastinum in search of thyroid and parathyroid tumours, although I had never knowingly dissected the thymus gland. Knowledge of the thymus was, indeed, everywhere somewhat sketchy, and the very text-books of anatomy do not give a great deal of precise information.

THE OPERATION OF THYMECTOMY

The thymus being a bilobed structure lying centrally in the anterior mediastinum, it seemed sensible, as recommended by Blalock, to approach through a midline incision, splitting the sternum down to the third or fourth interspace. This has been found to give direct access and complete exposure of the mediastinum, so that there was no need to complicate the operation by any transpleural line of approach. The details of the operation are as follows:—

1. The subcutaneous layers are infiltrated with adrenaline 1–500,000 in normal saline transversely

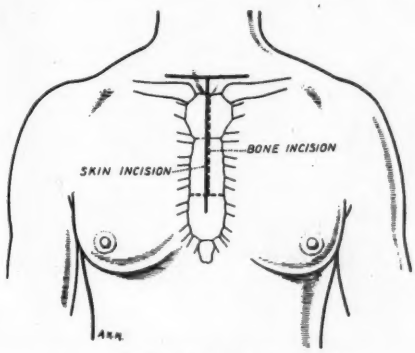


FIG. 246.—The skin and bone incisions.

above the sternal notch, and vertically over the centre of the manubrium and body of the sternum.

2. The skin incision (*Fig.* 246) is made in the same lines. Above the sternal notch it is deepened to expose the attachments of the sternothyroid muscles. Over the sternum the vertical incision is taken through the periosteum down to the bone, and extends as far as the level of the fourth costal cartilage. In the earlier operations I went as far

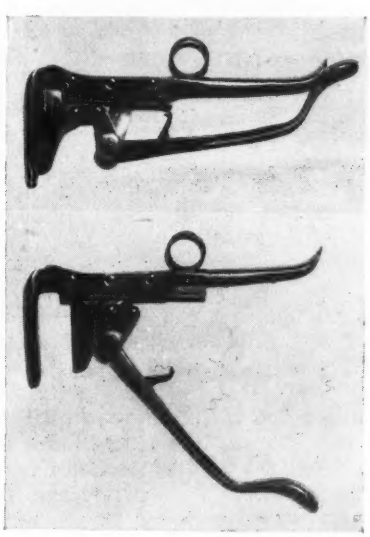
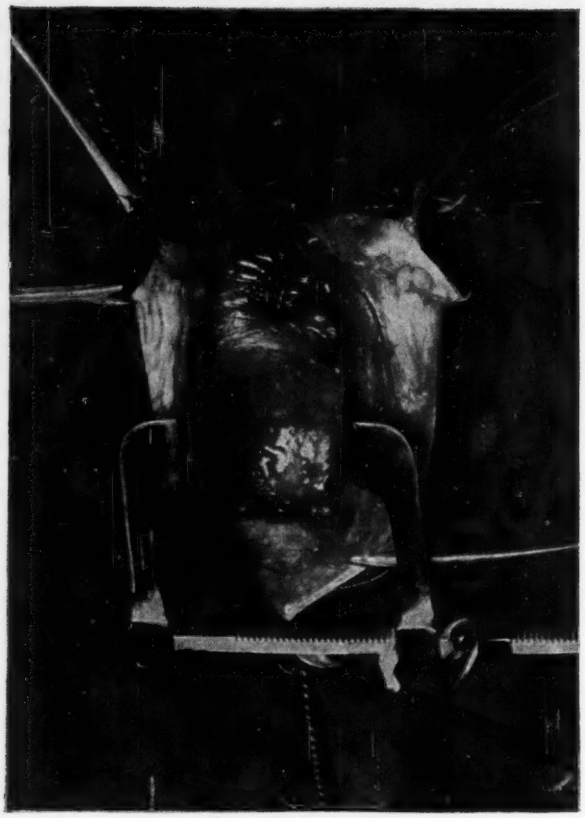


FIG. 247.—Schumacher's sternum splitter.

as the fifth cartilage in order to divide the sternum laterally into the fourth space. Afterwards this seemed to be an unnecessary infringement of the integrity of the thoracic box, upon which the patient depends for the maintenance of breathing, and I now divide the sternum only as far as the fourth cartilage.

* The specimen is in the St. Bartholomew's Hospital College Museum.



(*Photograph by Hennell.*)

FIG. 248.—The mediastinum opened.

3. A short incision is made in the midline between the sternothyroid muscles, and the tissues are separated by blunt dissection, so that the left forefinger can be inserted beneath the manubrium sterni. The suprasternal ligament, usually accompanied by a blood-vessel, is divided. At this stage the upper horns of the thymus, which usually reach to the thyroid isthmus, can be readily demonstrated (*Fig.* 250, inset), and these may be useful as a guide to the inexperienced operator in identifying the main bodies of the two lobes, but this is not essential.

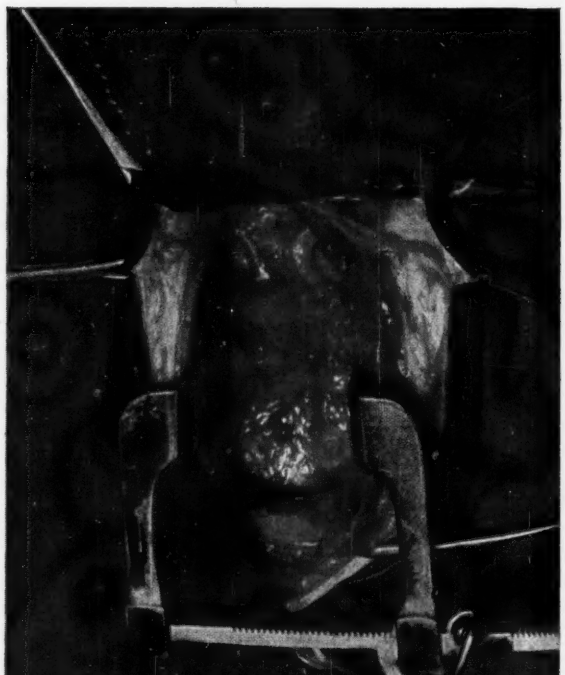
4. The left forefinger is now pushed beneath the sternum, and the connective tissues of the mediastinum are separated from the back of the bone.

5. Small flaps of periosteum are raised towards the third interspace with a rugine which is cautiously passed to just beneath the edge of the bone in the interspace. A curved blunt dissector is next passed into the mediastinum to separate the pleura from the bone without injury, and this is made to meet the finger exploring from above.

6. Schumacher's sternum splitter (*Fig.* 247) has seemed to be the most convenient instrument for cutting down the sternum, and the lower blade is now introduced underneath the sternum. It is removed when the central split has reached the level of the fourth cartilage, and the bone is then cut outwards on either side into the third spaces, a suitable pattern of rib-shears being used for this.

7. A strong self-retaining retractor is then put in place so as to lift and separate the two halves of the sternum. Bleeding during the process of sternum splitting is usually not severe, but if it seems excessive some Horsley's wax can be rubbed into the edges of the bone to control it.

8. When the mediastinum is exposed (*Fig.* 248), all the structures are still covered with a layer of connective tissue, and no details can be made out. This film is divided with scissors strictly in the midline, and the two lobes of the thymus gland, pinkish yellow, smooth, and firm, come into view. The pleura is closely applied to both lobes of the gland, and often covers them completely. This is peeled away with the utmost care, so as to leave both pleuræ intact if possible, and the full extent of the gland is gradually revealed (*Figs.* 249, 250). Often the lobes extend some distance around the sides of the aorta, and so come to lie right underneath the lungs. In the upper part of the mediastinum the lobes lie on the left innominate vein whence the upper horns extend into the neck. Below, the lobes spread out in thin sheets on the surface of the pericardium to which they find a firm attachment. They are separated by blunt dissection from all these structures, blood-vessels are clamped and tied with the finest catgut, and the gland is removed. It is usually impossible to identify with any certainty the branches supplying the gland from the internal mammary arteries, because they are so small. Bleeding is avoided by clamping and tying any likely-looking strands of tissue. The venous drainage of the gland is concentrated in two large vessels



(*Photograph by Hennell.*)

FIG. 249.—The thymus gland dissected.

running on the back of each lobe. These unite into one short trunk (*Fig.* 251), usually of considerable size, which drains the blood into the front of the left innominate vein. This thymic vein is invariably present, and is a possible source of dangerous bleeding unless it is securely tied. It must therefore be identified with certainty every time.

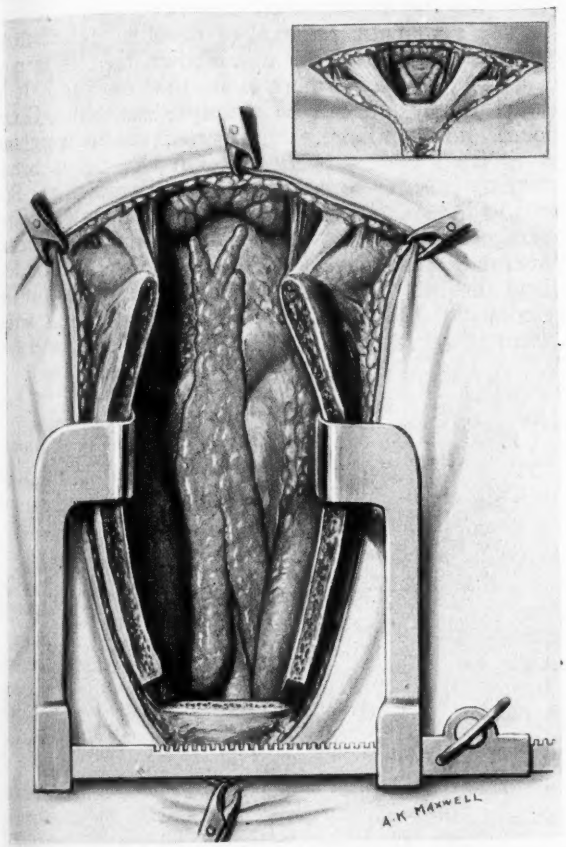


FIG. 250.—Drawing of dissected thymus.

9. This dissection should have exposed all the mediastinal structures already mentioned, and they should be left clear if the whole of the thymus gland has been removed (*Figs.* 252–254). The retractor is now taken out, the two halves of the sternum are allowed to spring back into their proper places, and the soft tissues over them are securely sutured in two layers with interrupted sutures of strong catgut. As Dunhill pointed out long ago, it is not necessary to fix the sternal halves with any special sutures through the bone, since they are held firmly enough by sutures superficial to the bone. This cancellous bone heals very rapidly, and only in one patient has non-union been observed. Approximation of the bone edges is made easier by lifting the patient's shoulders forward during the process of suturing.

10. The skin is accurately closed with fine sutures and clips, and dressings are strapped over the wound. It is important not to use any sort of bandage, since the maximum excursion of the chest must be maintained after operation.

The anæsthetic, given to my patients by Dr. Frankis Evans and Dr. L. H. Morris, is a pentothal induction followed by cyclopropane or gas and oxygen. The intrathoracic pressure must be fully controlled throughout the operation, and an intratracheal tube has been used for most of the patients.

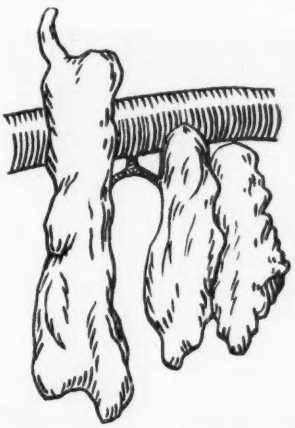


FIG. 251.—Showing the venous drainage of the thymus.

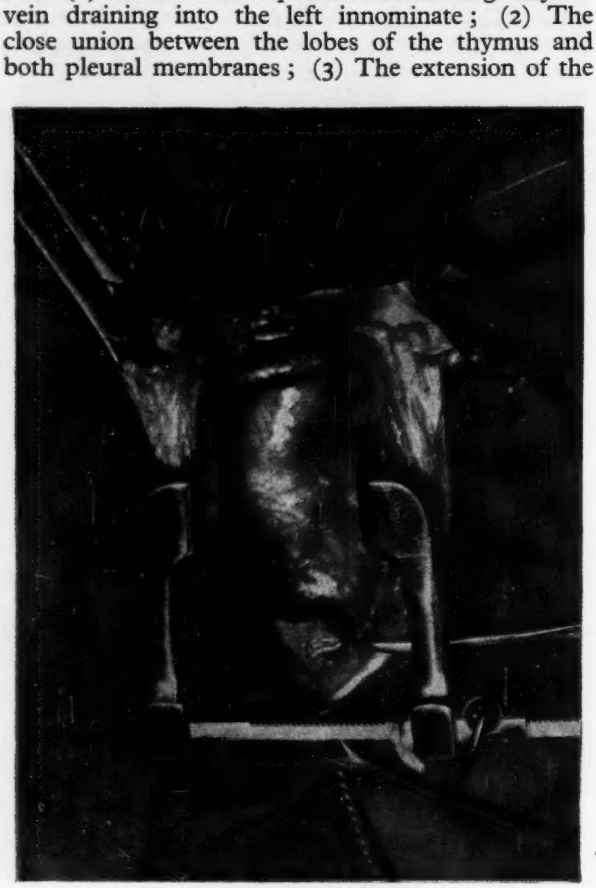
It is probably better, however, not to use the tube if the anæsthetist feels confident he can do without it, since this eliminates one source of tracheal irritation and mucus secretion.

(*Photograph by Hennell.*)

FIG. 252.—The gland removed.

Though the operation was described by Blalock as a tedious one occupying 1½–2 hours, I have found that it takes, without any hurry, an average of 60 minutes. Experience has shown that post-operative shock is not severe, and there is no necessity for great speed.

The anatomical points which may be emphasized are: (1) The invariable presence of the large thymic vein draining into the left innominate; (2) The close union between the lobes of the thymus and both pleural membranes; (3) The extension of the thymus far downwards over the pericardium and its firm attachments in this region. These three points serve to demonstrate the folly and danger of attempting to remove the thymus gland through an incision over the suprasternal notch without splitting the sternum. This operation was done by Sauerbruch in 1911 and has been repeated even in recent times, but it is unlikely to be practised in the future.



(*Photograph by Hennell.*)

FIG. 253.—The appearance of the mediastinum after removal of thymus.

THE THYMUS GLAND

It will be of interest at this point to consider in more detail the size, weight, and conformation of the thymus gland in the living adult subject. Ideas have been vague hitherto because the gland is not easy to identify in the dead body at post-mortem, and is almost impossible to isolate in its shrivelled state as found in the ordinary dissecting-room body. Furthermore, it has frequently been stated that the thymus is "abnormal" or "enlarged" in 50 per cent of the myasthenic patients who come to the post-mortem table, although it was very uncertain what was the normal size of the gland in adults, so that comparison was difficult. Careful investigations by Bratton (1925), Young and Turnbull (1931), and others, seem, however, to have established: (1) that the thymus is *relatively* largest just before birth, and that from this point it does not grow in proportion to the rest of the body; (2) that it is *actually* largest about the age of puberty, and gradually shrinks during the rest of the individual's life. Yet it is by no means so shrunken in normal adults as has been supposed, and it may weigh as much as 10–20 g. even up to the age of 30 or after. It does undoubtedly decline in old age, and since most dissecting-room bodies are those of aged people, the notion of the thymus being a thread-like organ has naturally gained currency.

The systematic removal of thymus glands from myasthenic patients has now shown that it is not, as a rule, grossly abnormal in this disease. It is always there, and can be readily identified. Occasionally it is very large. I have removed one weighing 31 g. from a man aged 37. On the other hand, another, from a woman of 36, weighed 2·7 g. But usually it is within the limits of normal. The average weight of 36 glands from myasthenic patients has been 15 g. The total weight of the gland has in any event no particular import in relation to disease. It usually consists to a large extent of lymphoid cells, connective tissue, and fat, whereas its activity presumably depends on the proportion of active epithelial cells, invisible to the naked eye, which do normally decrease after the age of 25.

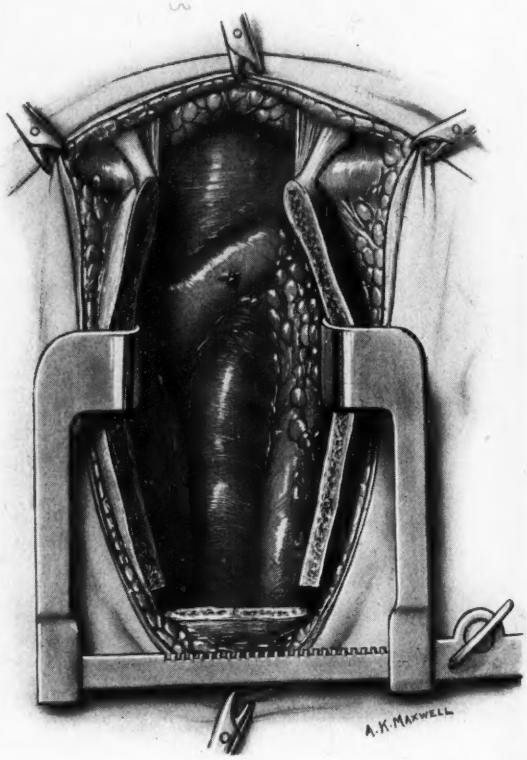


FIG. 254.—Drawing of the appearance of the mediastinum after removal of thymus.

The thymus is an elongated bilobed organ, extending from the thyroid isthmus to the pericardium. It may be as much as 8 or 9 in. long. There are varying degrees of union between the lobes in the midline. Apart from this there is very great variation in details of shape, as can be seen from the diagrammatic records of all the glands removed

(*Fig.* 258). The anatomical relations of the gland already described are fairly constant, though in the first patient I operated on the right lobe lay behind the left innominate vein instead of in front of it (*Fig.* 255), and in the twenty-fourth patient the whole gland lay behind this great vein (*Fig.* 256), making its removal a little more difficult.

FIG. 255.—Showing the right lobe of the thymus lying behind the left innominate vein instead of in front of it.

FIG. 256.—*Case* 24. Showing the thymus gland lying entirely behind the left innominate vein.

THYMOMAS

Reference has already been made to the occasional association of a thymic tumour with myasthenia gravis. This association has an important bearing on the treatment of myasthenia by thymectomy, experience having shown that any myasthenic patient may have a thymoma, often unsuspected. Blalock (1944), in his recent review of 20 patients treated by thymectomy, reported that he had found a benign tumour on 2 occasions. Both of these were successfully removed, and the patients were greatly benefited, one being apparently quite cured. The incidence of tumours in my series is approximately the same, 51 patients having produced 6 tumours. It seems, therefore, that at least 1 in 10 of the patients coming to operation is found to have a tumour, and the implications of this fact are of considerable importance. Both Blalock's tumours were benign, but of my six tumours one was already infiltrating the pericardium, pleura, and lung, and was judged to be inoperable. The patient died soon after the operation, and was found at autopsy to have compression of a main bronchus. It was evident that she could not have survived for very long in any event. The other five tumours were apparently benign, though their thick capsules were densely adherent to the pleura covering them and to the pericardium, thereby increasing the difficulty of removal and the risk of the operation, since it may be impossible to avoid opening the pleura widely. Thoracic surgeons do not regard opening the pleura as in any way affecting the outcome of their operations, and it is, in fact, part of their routine procedure. Myasthenic patients, however, have a very much smaller margin of respiratory reserve than other people, as well as a tendency to excessive secretion of mucus, and even a temporary collapse of the lung is to be avoided if possible. One of my five patients with benign tumours died after the operation from atelectasis of the lungs. The other four survived the operation, but two of them, after improving very greatly for a time, had severe relapses of the myasthenia and died within three months of respiratory failure. Only two of the six tumour patients are alive to-day; one, two years later, is very much better than before the operation. The other was operated on only recently. These apparently benign tumours are, as I have said, thickly encapsulated, but, nevertheless, they show a tendency to burst through this capsule, and histologically they consist of a homogeneous mass of epithelial cells in a state of great activity. Their appearance suggests to me that the margin between innocence and malignancy is rather fine, and I feel sure that the removal of these tumours at as early a stage as possible is of the greatest importance to the patient's welfare. Two patients whom we judged to be too ill for operation died shortly after we had first seen them and proved to have tumours, one of them malignant. We have noticed that all patients with tumours tend to respond more slowly and incompletely than most to prostigmine. The tumour may be of large size. One of mine weighed 66 g. with the thymus gland attached, and it is to be

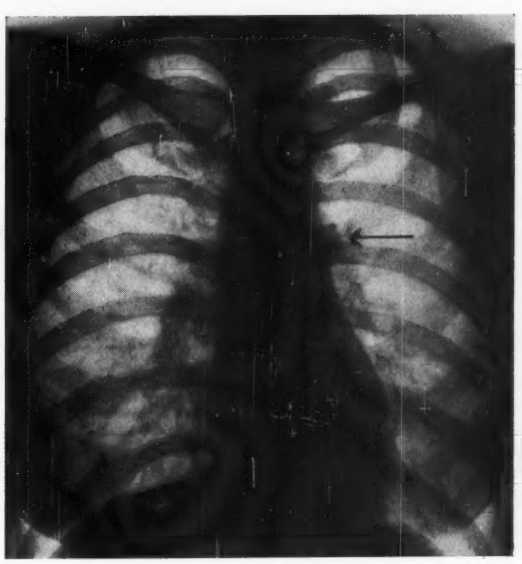


FIG. 257.—Radiograph showing shadow of thymic tumour (indicated by arrow).

expected that an encapsulated tumour of this kind would be demonstrable by radiography before operation. The ordinary myasthenic thymus can never be shown by X rays, being insufficiently opaque. The tumours can be demonstrated if they happen to overlap the shadow of the aorta, as is seen in one of my series (*Fig.* 257), but if they do not do so it may be very difficult to detect them. Clearly, however, X-ray examination should be part of the routine investigation before operation. The 10 per cent incidence of these very actively growing tumours is also a point in favour of thymectomy in an early stage of the disease, since it may be possible to forestall their appearance by so doing. Our experience suggests that when they occur the prognosis becomes very bad indeed.

RESULTS

All the 51 operations except one were done at the L.C.C. Hospital, New End, Hampstead, where I have been assisted by Mr. J. E. Piercy. The burden of almost the whole of the post-operative management has been borne by Mr. Piercy and the nursing staff at New End, to whose skill and assiduity many of the patients owe their lives. Dr. Carson and I were anxious from the outset that the issue should not be clouded by any doubts as to the diagnosis of myasthenia gravis in every patient, and the great majority were carefully observed by the physicians at Queen Square before being transferred to New End for operation. Most of them were also subjected to the test of injection of prostigmine into the brachial artery. This strengthens the flexor muscles of the forearm in the myasthenic

Case 3. Weight 10 g.

Case 5. Weight 8 g.

Case 6. Weight 10 g.

Case 7. Weight 7·5 g.

Case 8. Weight 8 g.

Case 9. Weight 12·5 g.

Case 10. Weight 16 g.

Case 11. Weight 9·5 g.

Case 12. Weight 31 g.

Case 14. Weight 8·5 g.

Case 15. Weight 19 g.

Case 16. Weight 11·5 g.

Case 17. Weight 5 g.

Case 18. Weight 23·5 g.

Case 19. Weight 11·5 g.

patient, but has the opposite effect in the absence of myasthenia. We believe that there were no errors in diagnosis, and we avoided, moreover, operating on any patients whose disease was so mild that they were able to live an almost normal life with the help of prostigmine. All our patients, in fact, could be described as severe or very severe examples of the disease, and most of them were maintained on very large doses of prostigmine, with or without ephedrine.

The youngest patient was 15, the oldest 54. Of the 51 patients 4 were under 20, and 7 were over 40, so that 40 came into the two decades 21 to 40. The duration of the diseased state before operation varied from 20 years to 4 months. In three-quarters of the patients the history was 5 years or less.

Of the 51 patients operated on 13 are dead and 38 alive. I will first consider the operative mortality. It must be realized that myasthenic patients present

Case 20. Weight 10·5 g.

Case 21. Weight 21·5 g.

Case 23. Weight 9·5 g.

Case 25. Weight 20 g.

Case 26. Weight 14·09 g.

Case 27. Weight 12·5 g.

Case 28. Weight 18·5 g.

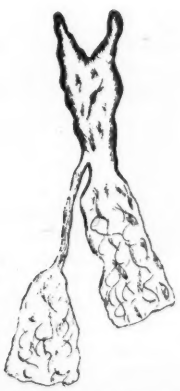
Case 29. Weight 2·7 g.

Case 30. Weight 23·5 g.

Case 31. Weight 13·5 g.

Case 32. Weight 20 g.

Case 33. Weight 21 g.



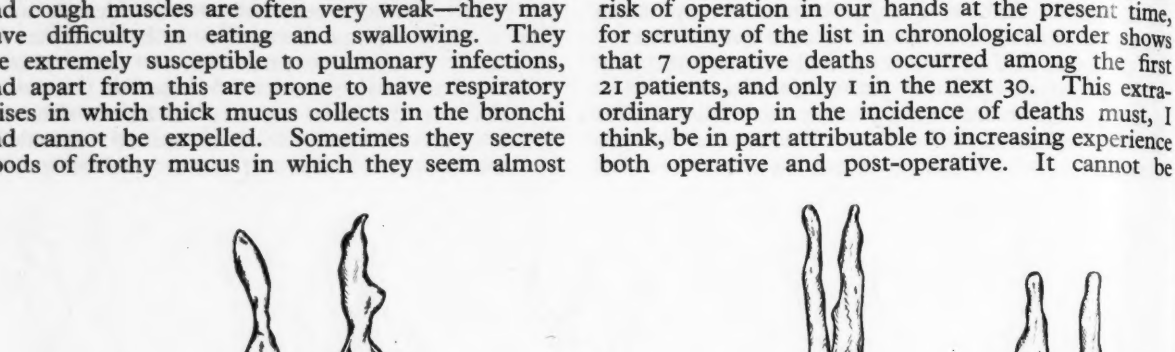
Case 34. Weight 18 g.

Case 35. Weight 21 g.

Case 36. Weight 17 g.

no ordinary problem in post-operative treatment. They are often greatly debilitated, their respiratory and cough muscles are often very weak—they may have difficulty in eating and swallowing. They are extremely susceptible to pulmonary infections, and apart from this are prone to have respiratory crises in which thick mucus collects in the bronchi and cannot be expelled. Sometimes they secrete floods of frothy mucus in which they seem almost

operative mortality of 16 per cent, but it is perhaps misleading to regard this figure as representing the risk of operation in our hands at the present time, for scrutiny of the list in chronological order shows that 7 operative deaths occurred among the first 21 patients, and only 1 in the next 30. This extraordinary drop in the incidence of deaths must, I think, be in part attributable to increasing experience both operative and post-operative. It cannot be



Case 38. Weight 14 g. *Case* 40. Weight 16 g. *Case* 41. Weight 6 g. *Case* 42. Weight 16 g. *Case* 43. Weight 17 g.

Case 44. Weight 15 g. *Case* 45. Weight 15·5 g. *Case* 46. Weight 14·5 g. *Case* 48. Weight 23·5 g. *Case* 49. Weight 16 g.

Case 50. Weight 7·5 g.

Fig. 258.—Semidiagrammatic drawings recording the size and shape of 41 thymus glands removed at operations, excluding thymomas (reduced to one quarter of actual size). (*Drawings by J. G. Wilson, H. J. Ashton, and Mrs. Raverat*).

to drown. Occasionally they suffer from an associated thyrotoxicosis which may be very severe. Looking back on our series it is a matter of surprise to me that of the 13 who have died, only 8 could be called operative deaths. This might be called an

all luck, though it may be argued that ill fortune did attend our efforts at first, since among the first seven deaths after operation were patients with: (1) a malignant tumour, (2) rheumatoid arthritis and brown atrophy of the heart muscle, (3) chronic

bronchitis, and (4) delirium tremens. The eighth patient who died had thyrotoxicosis and brown atrophy of the heart muscle. It is very noticeable that the operative risk is greatly increased by age. Four of the eight patients were in the small group of seven who were over 40. The other five patients who have died at intervals after operation up to two years all succumbed to respiratory infections which are so characteristic of the myasthenic state. Before the effect of operation on the disease is assessed, four patients will be described in detail.

Case 6.—A sailor, aged 22. Eleven months before we saw him he had noticed that speech became slurred after talking for a few minutes. A few weeks later he had difficulty in climbing ropes and ladders, and also developed double vision and difficulty in swallowing. The naval authorities then realized that he was not malingering, and he was invalided from the Service. He became rapidly worse, particularly in the evenings, and had to take 15 mg. of prostigmine before each meal in order to be able to eat. Thymectomy was done in May, 1942, and though he showed an initial improvement, he relapsed badly a fortnight after the operation, and nearly died in an acute myasthenic state. He just scraped through, however, and six weeks after operation had improved so much that prostigmine was no longer necessary. From that time he has been perfectly well and leading a normal life. It is now over three and a half years since the operation.

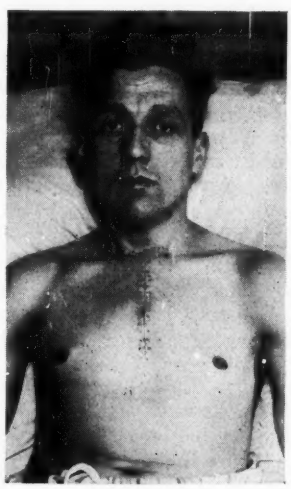


FIG. 259.—*Case* 3. The patient after thyroidectomy and thymectomy.

Case 3.—A member of the National Fire Service, aged 34 (*Fig.* 259). For nine months he had had pronounced symptoms of myasthenia which became rapidly worse, and for three months he had been quite helpless and bed-ridden. He was also acutely thyrotoxic with a pulse-rate of 130 and paroxysms of auricular fibrillation. We judged that the thyrotoxicosis must be dealt with first, and a partial thyroidectomy was done in May, 1942. He nearly succumbed to this, with auricular fibrillation and collapse of one lower lobe. He recovered, however, and six weeks later had no signs of thyrotoxicosis. The myasthenia, on the other hand, was worse, and he was very weak. He had recurrent respiratory crises with viscid mucus welling up from his lungs, and for these he had to have prostigmine given intravenously. Thymectomy was done in June, 1942. Rather to our surprise he survived this, and made steady progress, which has continued to the present time. He presented the unusual feature of partial atrophy of some muscle groups, and this delayed his regaining strength, but now three and a half years after operation, he is quite well and able to lead a normal life without prostigmine.

Case 14.—A fireman, aged 39. Twenty years ago he had noticed drooping of his eyelids, and was diagnosed as having myasthenia gravis of mild degree. In spite of double vision he was able to carry on his occupation

A B

FIG. 260.—*Case* 14. Photographs showing patient before (A) and after (B) taking prostigmine.

as fireman. Three months before he was seen he began to notice weakness of arms and legs, and he developed all the other characteristic signs of severe myasthenia gravis. *Fig.* 260 shows him before and after having prostigmine, which he could not take by the mouth because of retching and colic. Thymectomy was done in January, 1943, but this had no effect whatever on the symptoms. The disease was in an irreversible phase, and he died three months after operation of bronchopneumonia.

Case 37.—A farm foreman, age 34 (*Fig.* 261). For two months he had noticed a rapid onset of difficulty in

A B

FIG. 261.—*Case* 37. Photographs of patient before (A) and after (B) removal of the thymus.

chewing and swallowing. He had to support his lower jaw with his hand. When admitted to hospital he had severe signs of myasthenia, particularly facial, which

responded well, though slowly, to prostigmine. Thymectomy was done in November, 1944, and he was found to have a thymic tumour weighing 66 g. This was removed, and he made a dramatic recovery, so that he was discharged from hospital a month later apparently almost well and free from symptoms (*Fig.* 261). A week later, however, all his symptoms returned, and he died with acute myasthenia three months after operation. Nothing which could account for the relapse was found at the autopsy.

These four examples illustrate the extremes of success and failure, and there is much variation in between. We have had difficulty in deciding how best to classify the results, since there is no uniformity in the manifestations of myasthenia. It is easy to say if a patient is quite well, or if there is no improvement at all, but hard to assess intermediate states. We have in the end decided to recognize four categories :—

A. Quite well, normal life without prostigmine.
B. Greatly improved, but needing some prostigmine.
C. Somewhat improved, prostigmine less than before.
D. No improvement.

Of the 51 patients operated on 18 cannot be included in the results because of :—

Post-operative deaths	8
Mentally abnormal	1
Too recently done	9
	18

Thus, there are 33 to be classified, and a careful follow-up gives these results :—

A. Well	9
B. Greatly improved	11
C. Somewhat improved	8
D. No better	5

It is noticeable that all the patients in group *A* had short histories, the longest being two years; those in group *D* had long histories (6, 9, 20 years), or a tumour (2 patients); those in group *C* had long histories (4 to 16 years), or a tumour (1 patient); those in group *B* had histories varying from 4 months to 6 years, but more were short than long.

These observations seem to provide some answer to the questions that naturally arise as to prognosis. In brief, it is the younger patients with the shorter histories who will give the best response. Patients have now been apparently cured for as long as three years, so there seems to be some hope that the results may be permanent.

HISTOLOGY

The histology of the thymus gland is being investigated in detail by Dr. Collins, of Sheffield, and Dr. Bratton, of the L.C.C. Service. Glands, both from normal adults and from myasthenic patients, are being examined, and it has not been easy to detect any constant difference between them; but the investigators believe that they are now finding in most of the myasthenic glands an abnormal development of foci of clear cells resembling the so-called germinal centres of lymph-glands. It is just possible that these cells are derived from the epithelial elements of the embryonic gland, and that they are the real culprits producing the poisonous secretion responsible for myasthenia gravis. The Hassall's corpuscles, so conspicuous in all thymus glands, are likely to be innocent of all evil. The tumours removed consist of solid masses of large clear cells, also probably of epithelial origin. These matters will be reported on in detail at some future date.

BIOCHEMISTRY

In the future, too, lies the full investigation of myasthenic thymus glands by biological assay. The glands removed are being kept in cold storage against the time when Dr. Parks at the Mount Vernon Institute of the Medical Research Council will have time to devote to this problem. The investigation seems full of promise.

This paper describes a recent advance along one of the by-paths of surgery. Let it be remembered that seemingly unimportant by-paths may ultimately lead to main roads.

Acknowledgement.—The colour photographs (*Figs.* 248, 249 and 252, 253) were taken by Mr. Percy Hennell of the Metal Box Company, working on behalf of the Medical Research Council.

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CONSTRICTIVE PERICARDITIS*

By T. HOLMES SELLORS

SURGICAL intervention in disorders of the human heart is still regarded as something in the nature of a dramatic adventure, although in recent years it has been shown that the surgeon's hand is more kindly tolerated than was once thought possible. At the end of the last century Weill and Delorme were urging that in constrictive pericarditis 'c'est à la chirurgie qu'il appartiendra un jour de délivrer le coeur de la coque qui l'étrangle'. An occasional attempt here and there to free the heart from its trammels remained a surgical curiosity, and only in the past decade has it been accepted as a recognized procedure. Even now related experience is limited and variations of opinion exist in the surgical treatment of this crippling disease.

HISTORICAL

The local evidence of pericardial constriction is associated with other changes in the body, both of primary and secondary importance. Pick's disease is a title frequently used in this connexion, though it has been shown that priority of description definitely belongs to Richard Lower (1669). He clearly recognized the syndrome with the failure of the heart to relax fully in diastole as being the principle factor in the defective cardiac output. He also noted an inspiratory suppression of the pulse (pulsus paradoxus) and gave an explanation of this phenomenon, thus antedating Kussmaul (1873), whose name is usually associated with this form of pulse, by more than two centuries. The work of two English physicians, both from Guy's Hospital, also merits a recognition that has only recently been accorded it in American literature. Chevers (1842), from his post-mortem records, found no evidence of rheumatic origin in the pericardial adhesions whose contraction round the heart leads to " compressing its muscular tissue and embarrassing its systolic and diastolic movements, but more particularly the latter ". Wilks (1871) noted that " in a well-marked case of disease with cardiac symptoms in young persons without any valvular bruit pericardial adhesions may be fairly expected ". Other early references have been dealt with in Herrick's *Short History of Cardiology* (1942) and in the works of Paul White (1944).

The frequent use of the name of Pick (1896) in connexion with constrictive pericarditis is the outcome of a series of cases in which he differentiated between liver cirrhosis associated with and resulting from pericarditis and the enlarged icing-sugar liver which occurs in cases of polyorrhomenitis (polyserositis). About the same time the possibilities of active surgery were being considered by Weill (1895) and Delorme (1898) in cases of definite constriction. The study of the adherent pericardium which led up to Broadbent's classic description (1895) did, however, lead to considerable confusion, not yet fully clarified. The type of case with an enlarged heart, fixed apex beat, systolic recession, and diastolic shock should come under the heading of mediastino-pericarditis and be in no way confused with constrictive pericarditis. The whole picture of these two conditions is almost diametrically opposed, the only common factors that they possess being a pericardial pathology and interference with circulatory function.

The first surgical attempts to obtain freedom of action for the restricted heart were based on Brauer's operation of cardiolysis, in which costal cartilages and part of the adjacent sternum over the left heart were excised. Bourne (1924) recorded at least 25 cases and Smith and Liggett (1929) 107 instances of this operation, though the condition for which operation was undertaken was not one of pericardial constriction in the strict sense of the term. It seems probable at the present time that the Brauer type of operation has little place in cardiac surgery and none in constrictive pericarditis, though it is admitted that it may constitute the approach stage for the operation of pericardiectomy.

Constrictive pericarditis which ties down the heart movement and produces chronic compression can only be relieved by some direct form of excision of the cicatrized pericardium. Among early attempts at this type of surgery already advocated by Delorme were those of Rehn, Hallopeau and Sauerbruch, but the first comprehensive series of cases was published by Volhard and Schmieden (1923–6). The work of these last constituted the real foundation on which the present understanding and treatment of the condition is based. Churchill's first case in 1929 afforded considerable stimulus to the English-speaking world, and figures and accounts have been published by Blalock and Burwell, White, Churchill, Beck, Heuer, Harrington and others.

GENERAL PICTURE

By definition the essence of constrictive pericarditis lies in the fact that contraction of pathologically formed intrapericardial adhesions restricts the normal action of the heart. It is well known that adhesions can exist without obvious interference with function; on the other hand extrapericardial adhesions dragging on a diseased heart may add to its enlargement. At this point it is advisable to emphasize again the precise differentiation between the constrictive and non-constrictive forms of adhesion. Armstrong (1940) examined 114 collected post-mortems with extensive pericardial adhesions and found that in those cases (72 in number) in which the heart was enlarged there was evidence of some definite cardiac lesion. Compression of the heart was only recognized in 10 instances and here the adhesions were of such a type that they constituted a strong fibrous cuirass round the heart. Severe myocardial damage rarely, if ever, occurs in constrictive pericarditis.

* Being based on a Hunterian Lecture delivered at the Royal College of Surgeons, April 28, 1944.

Starting then with a constricting and limiting layer of dense fibrosis in the pericardial tissues, it is possible to see how increasing contraction brings about progressive impairment of cardiac function. The heart is practically strangled to death by cicatrization of its own investment.

The chief effect of the fibrosis is to limit diastole. The oncoming venous blood cannot be accepted in full amount by the restricted relaxation, and the pump, being insufficiently supplied, has less to deliver in its forcing stroke. It has not been universally recognized that the heart chambers are unable to receive the full amount of venous blood offered them. It has been suggested that constriction by scar tissue round the great veins could reduce the venous return and limit the heart output in this way: this supposition is probably erroneous and was based on the presence of narrowing and calcification round the caval orifices. It is possible that these channels can be reduced to a diameter of little more than a lead pencil without interfering with an efficient circulation, providing that the ventricles are sound; moreover, the improvement obtained by freeing only the ventricles suggests that their compression is the main factor in the production of the condition. In mechanical terms, then, the cause of the mischief lies in the fact that as the filling stroke of the piston is shortened the compression stroke cannot deliver its normal output, and in consequence the pressure in the supply 'main' will inevitably rise.

On the arterial side of the circulation the limitation of diastolic supply and consequent reduction of systolic output is recognized by a low level systolic blood-pressure (90 to 110 mm. Hg) and a low pulse pressure (15 to 25 mm. Hg being not unusual). In normal circumstances the response to exercise results in an increased output of the heart per beat associated with some increase in rate; factors which combine to give a substantial increase in the volume output per minute. In constrictive pericarditis the output per beat is limited and the only way in which the necessary volume per minute can be sustained is by an undue increase in the pulse-rate. Tachycardia is therefore a comparatively early sign and this becomes even more prominent on exertion. Dyspnœa similarly occurs on exercise, but is absent at rest, and does not occur when the patient is lying flat (an important sign in differential diagnosis). The presence of a paradoxical pulse is common and whereas a simple mechanical explanation as suggested by Lower may be adequate, a circulatory theory of causation as offered by Hitzig (1941–2) is also acceptable.

The effects on the circulation in constrictive pericarditis and other conditions producing chronic tamponade have been studied by Blalock and Burwell (1941), Heuer and Stewart (1939), and Hitzig (1941–2), with results which conform with most findings. The velocity of the blood-flow is reduced, the normal figure of 16 to 21 seconds between arm and tongue being prolonged up to 40 or 60 seconds. The heart output is definitely lowered to about 2 litres per minute (normal 3·87) and the output per beat may be reduced from 64 c.c. to 18 to 40 c.c. The blood-volume in the few instances in which it has been measured shows an increase of 30 to 40 per cent above normal. The oxygen content of the arterial and venous blood has also been estimated and the difference has been found to be exaggerated in constrictive pericarditis.

The most significant feature of the condition is the raising of the venous pressure—a direct response to the reduced heart output. Volhard referred to the phenomenon as *Einfluss Stauung*, which has been inadequately translated as Inflow Stasis. The venous return steadily becomes dammed back and, whereas a raised venous pressure may be of some help towards an improved output, the effects on other parts of the body are more far-reaching. In acute cardiac compression or tamponade, as Beck has pointed out, pressure on the heart which gives rise to a figure of 160 mm. water in the right auricle and cavæ is the point at which the circulation stops. In chronic compression the venous pressure can reach as high as 300 mm. or 400 mm., and the slow development of the stasis allows the peripheral systemic veins to become dilated and even tortuous. These veins appear on all parts of the surface and are particularly noticeable in the neck, head, and abdominal wall. Venous pulsation is an associated feature and its presence excludes venous obstruction as a cause of the distension. The actual pressure may be measured by observing the height to which blood will rise in a tube containing citrate solution connected through a needle to an antecubital vein. This vein should be held at the same level as the auricles, regardless of the posture of the patient. The venous signs in the neck are among the most important in the recognition of the condition and the approximate assessment of its severity. In the normal subject reclining at an angle of 45°, the external jugular veins are not distended, nor is pulsation in the deep veins visible above the supraclavicular fossa, since the level of the venous reservoir is about that of the angle of Louis. With the rise in venous pressure consequent on compression of the heart, the level in the venous reservoir rises, and thus the point to which the veins of the neck are distended. The measurement of increased venous pressure by taking the vertical height above the sternal angle of the pulsating junction between the distended and collapsed segments of the external jugular vein is a simple procedure.

Peripherally the effect of venous engorgement is most obvious in œdema in the dependent parts of the body, particularly in the legs, where in course of time the œdema takes on a lymphatic appearance. Facial and arm œdema may be present though they are not always noticeable, but swelling of the face has been seen to develop in the course of days when rapid constriction was occurring (*Case* 4). Cyanosis of varying degree is common and the extremities are blue, cold, and uncomfortable. These symptoms are out of proportion to the degree of dyspnœa, being more dependent on the raised venous pressure than on the unduly reduced cardiac output.

The organ on which the effects of the venous stasis are most marked is the liver. Liver enlargement with ascites is one of the cardinal signs of constrictive pericarditis; both are proportionally much greater than in a comparable case of congestive heart failure. Apart from other significant signs the enlarged belly is almost bound to attract attention,

and it is a salutary criticism on diagnostic ability that some cases which ultimately came to pericardiectomy had been previously submitted to Talma-Morrison types of operation for persistent ascites. The reason for the fact that the effects of raised venous pressure should fall so heavily on the liver may be in part due to the absence of valves in the main hepatic veins. This, however, does not account for the relatively greater engorgement in comparison with congestive heart failure, and it has been suggested that basal cardiac adhesions hold the orifices of the hepatic veins wide open, thus exposing them to the full brunt of the raised venous pressure. The enlargement of the liver may be so gross that the lower edge is below the level of the umbilicus, and when long-standing in a child may produce a marked 'pot belly' and outward winging of the costal margin. Where palpable, the liver is soft and occasionally tender. In the later stages perihepatitis produces an icing-sugar appearance, and the peritoneum shows thickening. Upper abdominal discomfort, fulness, anorexia, and in some cases pain are possibly attributable to the liver enlargement. In advanced cases in which there has been time for the raised venous pressure to damage liver tissue the loss of function may contribute to the failure of complete recovery that is sometimes seen after apparently successful excision of the constricting pericardium. The spleen is rarely enlarged and there is little evidence of interference with renal function.

The ascitic outpouring can reach considerable proportions, as has been indicated, and presents in many cases the characters of a transudate. It is possible, however, that a coexisting inflammatory exudate may also be present as the result of peritoneal irritation. In one case in the present series the finding of tubercle bacilli in this fluid afforded direct evidence of this point, and it is probable that in many instances of multiple effusions with cardiac compression the ascitic fluid is a combination of a transudate and exudate. The rate of re-accumulation after paracentesis is variable, dependent to some extent on fluid intake, diet, and drug administration, but on the whole fluid is formed most rapidly in the early stages while the constriction is developing. In later years thickening of the serous membrane appears to delay fluid production.

Other effects of less clinical significance include raising of the cerebrospinal fluid and lymphatic pressures. Effusion into the pleural cavities is generally accepted as part of the constriction complex, but our observations suggest that a pleural transudate is extremely rare and that the effusion has the character of an inflammatory exudate, being often unilateral and transitory. In other words, pleural effusions are probably part of a polyorrhomenitis (polyserositis), rather than a sequel to constrictive pericarditis.

A remarkable feature in all this interference with the circulatory system is that the lungs are unaffected. Admittedly the pressure from the abdomen reduces their capacity to a small extent, but congestion is, clinically and radiologically, absent. The explanation is that the restricted diastole of the right ventricle allows only a limited output of blood into the pulmonary vascular bed, and this amount is easily dealt with by the left heart without raising the venous pressure in the lungs. This has a definite bearing on the surgical technique of pericardial excision, for if the right ventricle is liberated before the left the suddenly increased output into the lungs may lead to severe pulmonary congestion, since the limited stroke of the left ventricle cannot accept the greater volume from the lungs. Congestive heart failure, be it noted, is invariably accompanied by some pulmonary engorgment and occasionally hæmoptysis, so that the presence or absence of these features is important in differential diagnosis.

Such symptoms as lassitude, wasting, and weakness are regularly encountered and can be understood in the light of the general interference with the circulation. The rate of development of the constriction plays a considerable part in establishing the symptom complex. A gradual onset in middle age may be associated with vague complaints, such as tiredness and slight shortness of breath with dyspepsia, but a more acute course in a child leads to rapid loss of weight, distress, coldness, and a general arrest of development.

In summary it may be said that the essential features of chronic cardiac compression are based on the increase in the venous blood-pressure, with consequent engorgement and œdema. Ascites and an enlarged liver are constant findings. To complete the classical triad of the compression syndrome, according to Beck, a small quiet heart should be added. This, however, requires qualification, since a reduction in the apparent size is by no means always seen, but the presence of a 'quiet' or practically immobile heart can be emphasized.

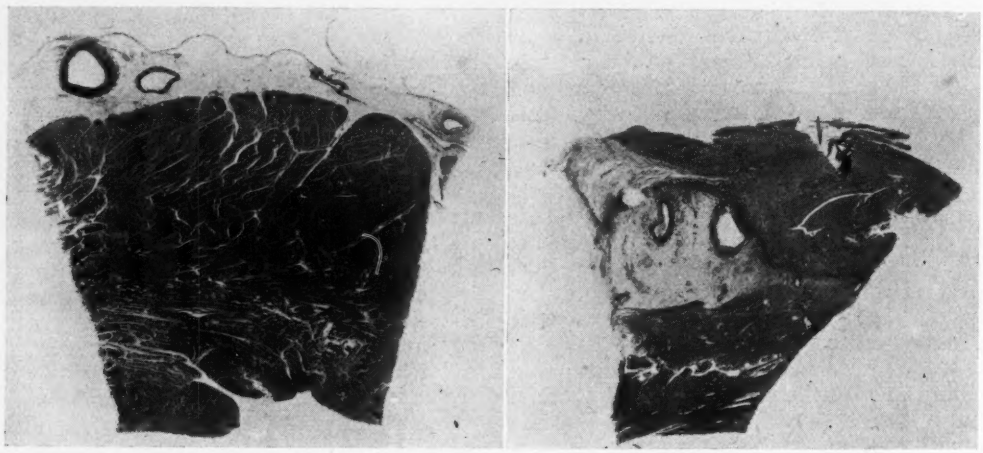
STATE OF THE HEART

One of the fundamental points of constrictive pericarditis is that the heart muscle is normal in nearly every case. The myocardium is not diseased and it is potentially sound, though its activity has been sorely restricted in the process of constriction. If the restraining pericardium is removed the myocardium in the course of time is able to function with a power that approaches normal. Moreover, the condition only embarrasses the patient's existence when the local mechanical state has jeopardized the circulation as a whole.

Some evidence has been advanced to suggest that disuse atrophy of the myocardium may possibly result from prolonged constriction of the muscle-fibres. A postural 'contracture' might almost be expected, but the only direct evidence is provided by Roberts and Beck (1941), who found that the average diameter of the heart muscle-fibre (in a few post-operative hearts examined) was reduced from 13·9 μ to 9·9 μ. It has further been suggested that the constricting fibrous tissue may produce narrowing of the coronary vessels with subsequent atrophy of muscle, but in our investigations this has not been apparent (*Fig.* 262). It seems probably that after successful pericardiectomy the muscle power is not up to its normal standard, but in the course of the months the muscle strength re-develops.

Whereas the heart muscle itself is relatively normal the same cannot be said about cardiac rhythm. The presence of contracting scar tissue

and even plaques of calcium around the 'pace-making' area may account for irregular stimulation. All types of irregularity from occasional extrasystoles to established auricular fibrillation may be encountered and periodic changes of rhythm are not uncommon. Operative handling of the heart produces extrasystoles and sometimes fibrillation, though these disturbances, even if they are more than transitory, generally subside within twenty-four hours. Any pre-existing irregularity is not necessarily replaced by normal rhythm after surgical removal of the pericardium, though it has been so on rare occasions. In one of our cases (*Case* 2) alternations of flutter and fibrillation were observed between periods of normal rhythm.



A B

FIG. 262.—Section through a branch of the coronary artery. A, Normal; B, Constrictive pericarditis (*Case* 3). The subject from which A was taken was two years older and of appreciably greater stature than the subject of the pathological specimen.

FIG. 263.—Calcified constrictive pericarditis (*Case* 5). Calcium forming an irregular meshwork round the auricles and great veins is more visible in the lateral than anteroposterior views.

It is commonly presumed that the heart is small and immobile as a result of constriction, and in most established cases this is so, but in early constriction the added thickness of the pericardium may even give an impression of enlargement (*Cases* 1, 4). It is important to realize that one of the three supposedly cardinal signs of chronic cardiac compression, viz. a small heart, cannot be relied on.

The diminished range of movement of the heart is similarly not always obvious. Admittedly the apex-beat is rarely to be felt and the heart-sounds are distant and obscured, but a palpable apex-beat and audible heart-sounds are not incompatible with constrictive pericarditis. Murmurs are rare, but when calcification has occurred some adventitious sounds may be elicited, e.g., the high-pitched protodiastolic vibration of Lian. The range of heart movements can only be assessed by radiology, where screening and kymography are both of value. Screening gives a most accurate picture, since all available aspects of the heart outline can be viewed; kymography gives a more permanent record which can be examined and analysed at leisure. All borders of the heart must be observed for pulsation and it will probably be found that the limitation of movement is not uniform. A fixed left heart border, for example, may be accompanied by some movement of the right border, which, however, is in reality a thrust on to the weakest area of the constricting tissue. Undue elevation of the diaphragm and pleural effusions may add to the difficulties of screening, but our experience shows that screening is an imperative part of diagnostic investigation. An increased width at the upper part of the heart shadow is always to be seen, owing to engorgement of the superior vena cava and innominate veins. Other radiological points to be noted are calcification in plaques or bands,

reduced excursion of the aortic arch, and raising of the heart on swallowing (the swallowing sign of Rabin). Calcification appears in a quarter to a third of all cases, and films in different angles and of different penetrations may be necessary to demonstrate its presence (*Fig.* 263). It must be remembered that calcification of the pericardium can occur without constriction.

Electrocardiography shows remarkably uniform results, the principle features being a low-voltage type of curve and lowering or inversion of the T-wave (*Fig.* 264). The loss or inversion of the T-wave is commonly seen in Leads I and II and contrasts with pericardial effusions, which exaggerate

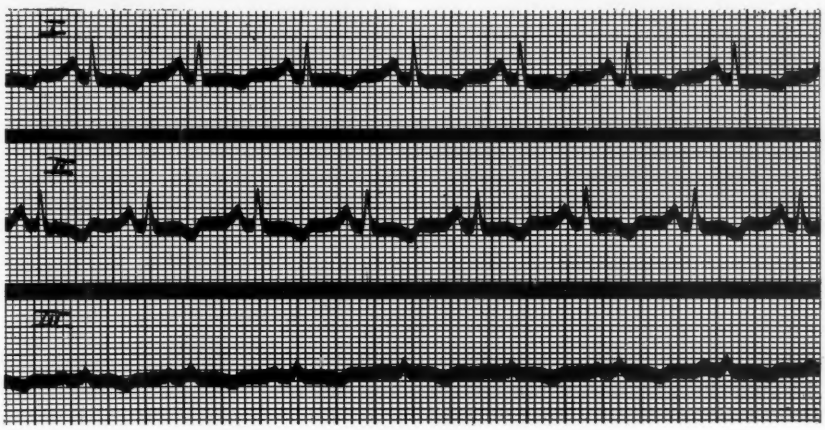


FIG. 264.—Electrocardiogram from case of established constrictive pericarditis. Note low-voltage curves and inversion of T-waves.

RS-T and the T-wave. Investigations of electrocardiographic changes have been made during operation (Stewart and Bailey (1941), but there is little to suggest that there are any notable changes apart from alterations in rhythm. After pericardiectomy there is some improvement in the voltage and a tendency for the T-wave to become less flat or inverted, but this is not marked for some time after effective liberation of the heart.

Aetiology and Pathology.—Rheumatic fever must be excluded from any share in the causation of constrictive pericarditis. The post-mortem studies of Wenkebach (1907), and Smith and Willius (1932) have revealed a high incidence of pericardial adherence which is of rheumatic origin, but that this type of adhesion does not lead to constriction is confirmed by observation over years (Chevers, 1842; White, 1935) and by pathological observations by Armstrong (1940) and the writer. The rheumatic adhesion is thin and vascular with loosely packed wavy collagen fibres. It is not the heavy hyaline collagenous type which heralds cicatrization and contracture.

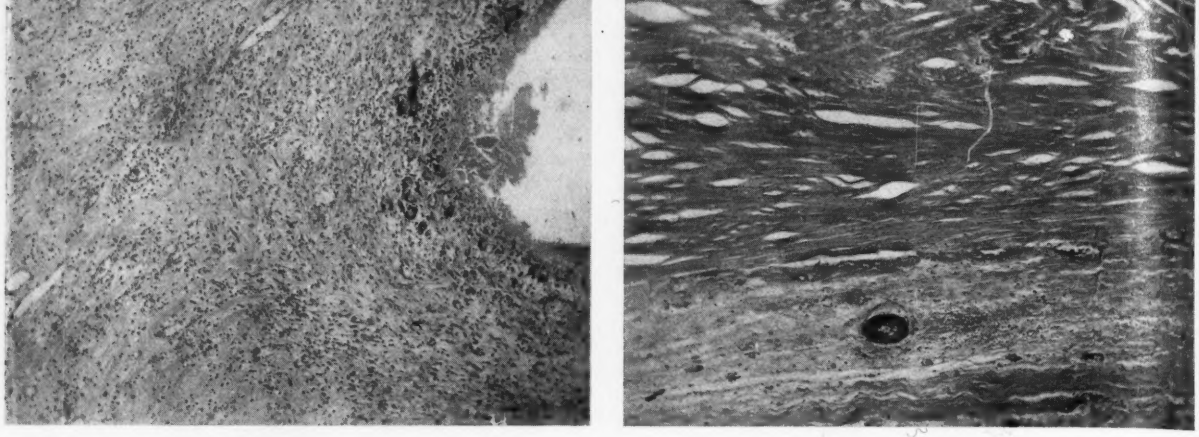
Current literature submits three possible causes for the origin of constriction—tuberculous infection, old pyogenic pericarditis, and idiopathic factors. This last accounts for the largest group in the published records, but it is easy to understand that the limited tissue available for microscopical examination from pericardial excision and the duration of the disease fail to afford complete facilities for investigation. It is interesting to note that White (1935), in reporting one of Churchill's operation cases, found tuberculous tissue in the original specimen, but on re-operation at a later date the excised pericardium showed only fibrosis. The significance of this observation should not be overlooked. Blalock and Burwell (1941) have admitted tuberculosis as a dominant factor in their series of cases, but generally tuberculous infection is only accepted as a positive aetiological factor in a small proportion of cases. Our own evidence strongly supports tuberculous infection as the chief causative agent, an opinion based on general clinical grounds, on the evolution of the condition, and on pathological evidence. Out of 5 operation cases and 15 others observed, tuberculosis was evidenced in 16. The massive avascular collagen of extremely hyaline character in long-established cases suggests that the condition is the end-result of a widespread and devastating inflammation with great destruction of tissue. This picture is similar to that seen in advanced healing stages of tuberculous inflammation and is strong evidence (in the absence of more direct findings) of this infection (*Fig.* 265).

A small number definitely owe their constrictive origin to a suppurative pericarditis. Many cases of staphylococcal infection which have been adequately treated, go through life with no further evidence of trouble, but where there has been insufficient aspiration or drainage and the patient has survived, the possibilities of constriction supervening at a later date are considerable. In this group the constricting membrane appears to be unduly thin, uniform, and tough, and calcification is not recorded.

The effect of chronic pericardial inflammation is most marked—as in the case of the pleura—on the parietal layer in the initial stages, but—again comparable with pleural inflammation—it is the restricting influence of the thinner visceral layer which is functionally more important. Pockets of fluid or inspissated pus and débris are often present. Plaques of calcium tend to burrow into heart muscle, and these, though of relatively minor importance over the thick-walled ventricles, are potential sources of danger elsewhere. Adherence of epicardium to muscle in the various grooves of

the heart (auriculo-ventricular, line of coronary vessels) is firmer than in other parts, and the development of fine blood-vessels between muscle and pericardium accounts for the punctate hæmorrhages that are encountered at operation.

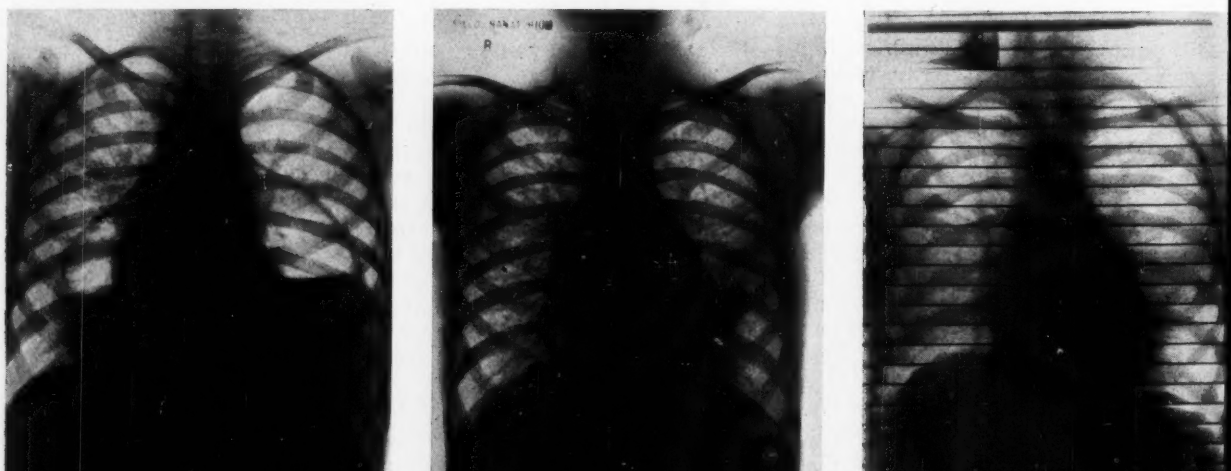
Development of Constriction.—In a few patients it has been possible, over a long period, to watch the actual production of pericardial constriction. These came under observation long before the syndrome developed and in two instances



A B

FIG. 265.—Microscopical appearances of excised constrictive pericardium. A, Tuberculous, showing vascularity, tubercle systems, and large giant cells (*Case* 3). B, Fibrosis of no definite origin. Avascular tissue with hyaline collagenous bundles (*Case* 2). (× 50.)

Extreme fibrosis around the caval and auricular regions is occasionally seen, and has already been mentioned as the site, according to some writers, at which obstruction to venous inflow occurs. It showed extensive pericardial effusions, suspected but not proved to be of tuberculous origin. Associated tuberculous lung lesions were present, but aspiration of the pericardium for relief of tamponade



A B C

FIG. 266.—Evolution of tuberculous constrictive pericarditis (*Case* 1). A, Enormous pericardial effusion producing cardiac tamponade after aspiration and gas-replacement. The size of the heart is demonstrated and also thickness of pericardium. Note pulmonary infiltration in upper part of right mid-zone. B, Pericardium fully contracted round the heart. Note hardening of lesion in right lung. C, Kymograph taken some months after operation. Free excursion of left heart border, with almost complete fixity on the right.

is highly doubtful that the constriction could ever produce such a degree of stenosis that a direct surgical attack on this region should be necessary. Fibrosed extrapericardial adhesions to pleura and precordium are constant, but unimportant, associates of the constrictive process.

on no occasion revealed tubercle bacilli. It should be remembered that a membrane covered by active and ulcerative tuberculous tissue may produce an effusion which does not reveal bacilli, even after careful examination by culture and guinea-pig inoculation.

With a chronic effusion the pressure of which is unrelieved the signs of tamponade become indistinguishable from those of early constriction (*Fig.* 266). The veins of the head and neck and upper extremities become engorged, the liver enlarged, and ascites is present. These signs persist and become accentuated as constriction develops, and undoubtedly the circulatory disturbance has a definite adverse influence on the general condition of the children. Stunted growth, extreme emaciation (masked to some extent by ascites and œdema), coldness of the hands and feet, and a general picture of apathy and lassitude predominate. The fingers

FIG. 267.—Appearance of child twelve months after pericardial excision. Even in absence of ascites note enlarged belly and general shape of the trunk (*Case* 1). Incision scar touched up by dotted line.

occasionally show clubbing, nails and hair are of poor quality and brittle, and the intellectual development is generally retarded. The shape of the body produced by the enlarged belly has already been mentioned (*Fig.* 267).

The future of a patient with constrictive pericarditis depends on the rate of development of the condition. The slowly developing case which is not submitted to careful and systematic investigation may pass through many hands before the disease is finally diagnosed. These patients can live for years in limited and tolerable health, as was evidenced by Nils Finsen (1904), who, having fallen ill at the age of 23, developed the classical signs, and though incapacitated survived 21 years, during which period he received a Nobel Prize for his work. But this is exceptional; few survive to old age, and the increasing distress and incapacity of the established case is a very strong indication for operation, which is even more urgent with quickly developing lesions. A slower course makes diagnosis more difficult, and the indications for surgery not apparently so imperative.

Under control there is little risk of harm during any period of observation. The heart muscle will not suffer from the constricting effects so long as it is not subjected to further strain; effusions can be relieved by aspiration; and re-accumulation retarded by low fluid intake and the use of mercurial and other diuretics. Prolonged rest is, in our view, imperative in children and youths, where there exists a possibility that the causative process has not been stabilized. The likelihood of tuberculosis as a aetiological factor makes it equally important that active disease should be given adequate chance to heal. In one example in the present series a tuberculous peritonitis and spine developed during observation, and another died of miliary tuberculosis.

The relationship of constrictive pericarditis with polyorrhomenitis (polyserositis) is probably more intimate than commonly supposed. A connexion is recognized, but the multiple serous effusions are often regarded as being *post hoc*, whereas their presence may precede constriction. Effusions as a possible part of a generalized tuberculous process may herald pericardial fibrosis, and as constriction develops the serous effusions persist and even increase—the raised venous pressure producing a transudate the volume of which is added to the original inflammatory exudate.

ROLE OF SURGERY

Removal of the restraining pericardium to allow as full a ventricular expansion as possible is the only treatment for established pericardial constriction. Excision of all the pathological pericardial tissues would be the ideal; this is not practicable, but the improvement following a limited removal is remarkable. Excision should aim primarily (and possibly only) at freeing the ventricles, though for anatomical reasons even this is rarely achieved. The usual procedure is to resect the anteriorly placed pericardium and to carry the dissection outwards over the apex and round the left border of the heart. The very thinness of the auricles and great veins makes interference over them a hazardous undertaking (*Figs.* 269, 270). Attempts to perform an extensive ventricular clearance without opening into the left pleural sac often results in a more limited operation being performed than was originally planned. To free the left border of the heart to an adequate extent the dissection should be carried posteriorly beyond the line of the phrenic nerve: but to do this and at the same time to preserve the integrity of the pleural cavity is practically impossible. Consequently a deliberate transpleural approach to the heart may be countenanced as readily as the more popular extrapleural exposure.

Where the signs are not too severe the probability is that a very limited operation may be performed with some definite relief of symptoms, and, on the whole, where difficulties arise it is better to limit the extent of the operation and remain within the bounds of safety. This policy, however, needs some critical qualification from the point of view of the end-results, which tend to show that a more extensive removal of pericardial tissue would have been advisable.

The incision through pericardium should be carried through both layers down to the heart muscle

and not only through the parietal layer (*Fig.* 268). This must be emphasized, because it is quite easy to find a plane of cleavage between the parietal and visceral pericardium even after years of apparent adherence. The dissection plane between visceral pericardium and myocardium is nothing like as easy to define (*see Fig.* 270).

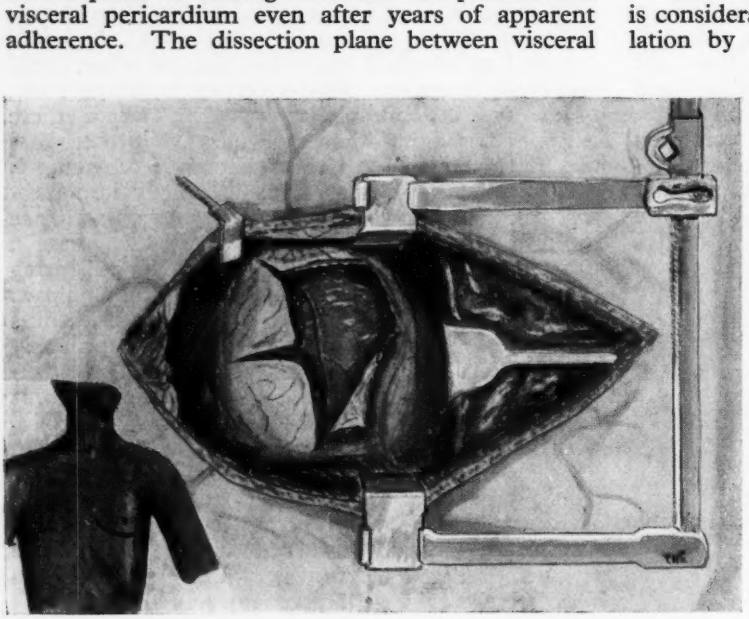


FIG. 268.—Appearances in the initial stages of pericardial resection (*Case* 5).

The most convenient site for starting excision is over the anterior part of the right ventricle, but the dissection should soon be carried over to the left ventricular region, so that the sudden release of the right heart does not lead to overloading of the pulmonary vascular bed until the stroke of the left heart is ready to receive it. The interventricular junction is marked by the slightly tortuous course of the descending branch of the left coronary artery —a vessel that on no account must suffer damage. Undue firmness of the constricting scar at this point may make it advisable to stop dissection and start again beyond the vessel, thus leaving a narrow strip of pericardium attached along its course. Once the correct plane has been reached a flap of pericardium can usually be raised by blunt dissection, though irregularities in thickness or structure (e.g., a calcified plaque) may necessitate a change of direction until the area can be more clearly defined. The use of a knife or scissors can be considered where undue adherence occurs. Flaps of pericardium should be kept intact until the completion of the dissection, when they can be cut away; they act as retractors and are available for closure of rents or tears in the heart muscle should this misfortune arise. At no time is it wise to carry dissection beyond the range of vision or unimpeded access.

The full aim of dissection is to free the anterior surface of the right ventricle and the front part of its diaphragmatic aspect, and to free the left border of the heart down over the apex well on to the diaphragm and to complete excision laterally behind the level of the left phrenic nerve (*Fig.* 269). The obliquely placed auriculo-ventricular groove marks the upper limit, and though clearance beyond this area is frequently advocated it can be seen from a section of this region (*Fig.* 270) that there is little margin for error.

The tolerance of the heart muscle to handling is considerable. The ventricles respond to manipulation by repeated extrasystoles and are liable to fibrillate if touched too often and too much; consequently periods of rest should be a routine part of the operation. During these intervals small warm packs or muscle-grafts can be applied to bleeding areas on the freed heart muscle. The possibility of cardiac arrest is present, but with the heart practically under manual control this need not be too alarming; 5 c.c. of 1 per cent procaine injected intravenously is said to be of value in controlling an unduly turbulent heart.

One of the most dramatic aspects of operation is the way in which the heart may leap to freedom as its casing is peeled away. The freed muscle bulges out of the excised area (adding to the difficulties of dissection) and will sometimes stand from 1 in. to 1½ in. away from its original bed (*Fig.* 271). Undoubtedly though the muscle may be normal the sudden release is associated with some over-stretching, since there is exaggerated pulsation and a greatly increased bulk of the heart. This, however, usually quietens down within a week of the operation. It may be that some of the post-operative deaths are due to this dilatation with fibrillation, and it might be wise to stage the operation if the access to freedom is too violent and looks like being uncontrolled.

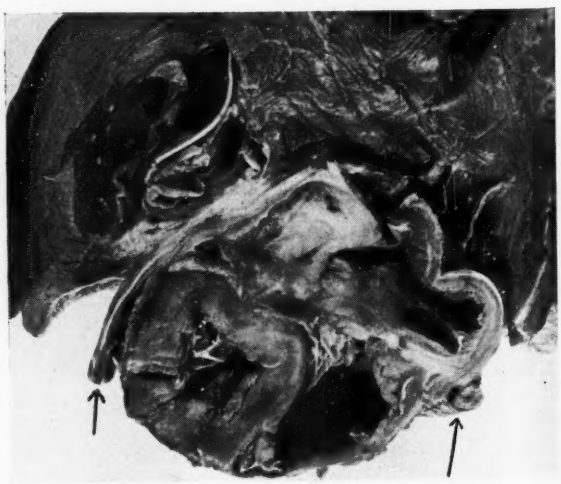


FIG. 269.—Post-mortem appearances of heart after pericardiectomy to show extent of dissection. Edges of excised tissue are indicated by arrows (*Case* 3).

A few cases do not show this operative exuberance; the muscle is easily dented and the heart remains the same size. This does not necessarily imply wrong selection of the type of case suitable for surgery, but is more likely to indicate that the constrictive process has not fully developed: in other words the condition is one of constricting rather than constricted pericarditis (*Case* 4).

Indications and Preparation.—Direct attack on the heart surface cannot be entertained lightly. Most careful assessment of the case and correct timing are essential so that the circulation is relieved of as much strain as possible. The diagnosis may even be in doubt and then a considered exposure of the heart is fully justified to demonstrate the state of the pericardium and to proceed if required. Subject to the ability of the patient to withstand adequate oxygenation can be provided. The anæsthetist must be prepared to deal with an open pleural cavity and may require tracheal intubation, though controlled respiration is hardly necessary. Chloroform and trilene are usually excluded on the grounds of toxicity, and gas-oxygen alone does not allow a high enough oxygen concentration. Local anæsthesia has its supporters, but it is not satisfactory if the pleural cavity is opened, and if used

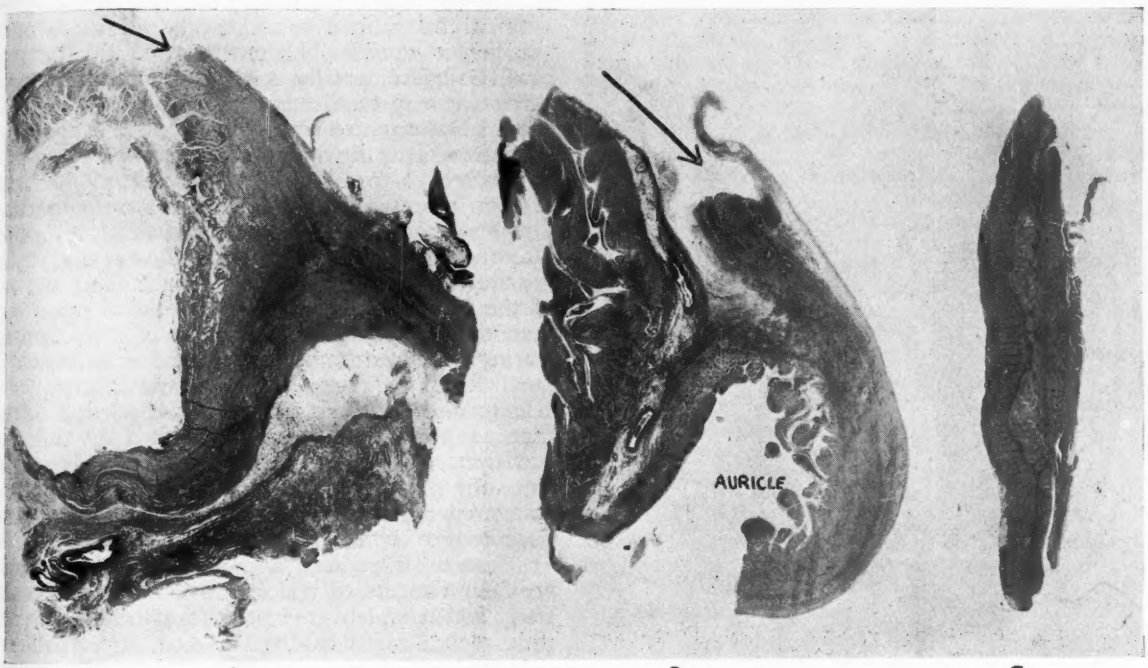


FIG. 270.—Sections through heart after pericardiectomy (*Case* 3). A, Posterior diaphragmatic surface of heart. Arrow indicates cut edge of pericardium. Note firm attachment of heart muscle, pericardium and diaphragm to each other. B, Auriculo-ventricular groove. Ventricle has been freed. Note thinness of auricle wall and the difficulty that would be encountered if pericardium were to be excised from this area. C Excised pericardium. Lamination indicated the plane of fusion between parietal and visceral pericardium.

the operation, every case of true constrictive pericarditis is eligible for surgical consideration. Conservative measures, no matter how careful and prolonged, can only be palliative.

If, as we believe, tuberculosis is the most potent causative agent, all precautions must be taken to see that the disease is reasonably stabilized before operation. Too little attention is sometimes paid to radiographic evidence in the chest and elsewhere.

Preparation for surgery consists of rest for a reasonable period and relief of the pressure of serous effusions. Paracenteses will be required and the volume of the effusions can be controlled to some extent by limiting the fluid intake and maintaining high output with mercurial diuretics. The use of mersalyl over long periods has not been associated with ill effect. Preclusion of fluid into the serous spaces also demands a low salt intake, and if the plasma proteins are low a high protein content diet is indicated. The use of quinidine, if the heart is unduly irritable, has been advised, but there is no place for digitalis therapy.

Anæsthesia.—The choice of anæsthetic agent is largely an individual problem, subject to the proviso that the agent used is not toxic and that at all should be confined to the exposure stages. In the present series Dr. Parry Brown has used reduced premedication followed by gas-oxygen-ether or cyclopropane throughout the operation. The alleged irritant effect of cyclopropane has not been found significant and there were no untoward occurrences during the operations. In all cases the patient was flat on the table; no particular benefit was derived from raising the patient's head.

Blood transfusion is not indicated, but we have had blood available in case of any sudden or unexpected hæmorrhage. The congested veins have the advantage of being readily accessible should intravenous therapy be required.

Exposure.—The heart can be reached in two ways, one aiming at exposure without entering the pleural cavities, the other working deliberately across the left pleural cavity.

The extrapleural approach can be made through an incision which starts along the line of the 2nd or 3rd left costal cartilage and extends down the midline to end along the line of the 6th left cartilage. The skin-flap and underlying muscle are reflected outwards, and the 3rd, 4th, 5th, and possibly 6th costal cartilages are resected with a small piece of

the adjacent ribs. The exposed internal mammary vessels, if not already injured, are ligated at the top and bottom of the wound and the left pleural sac which lies under most of the exposure is reflected away from the midline by blunt dissection. A moderate degree of firm adhesion is to be expected. The heart lies more deeply than might be supposed and further exposure may be gained by punching away pieces of the left sternal border (*Fig.* 271).

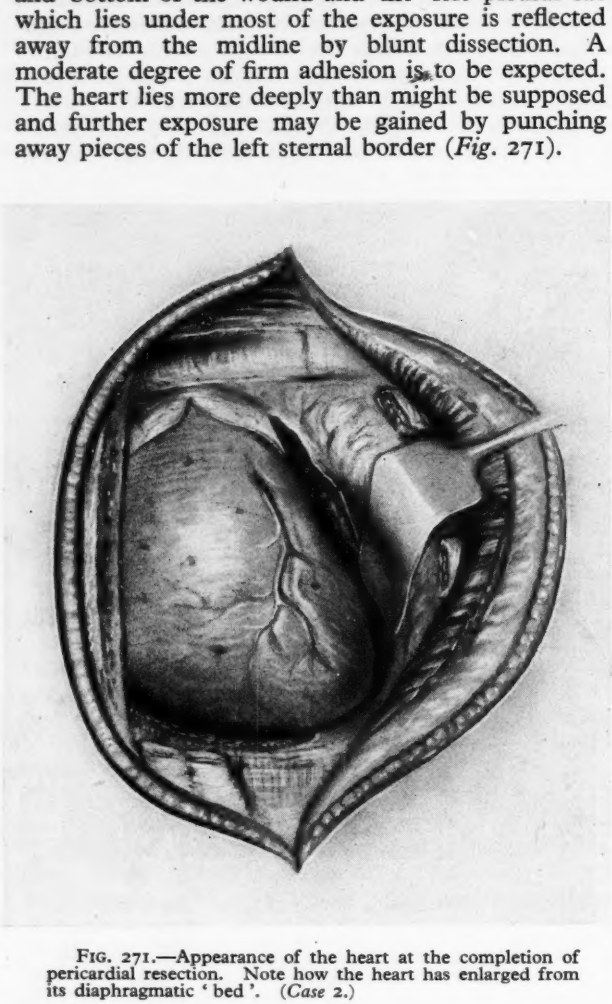


FIG. 271.—Appearance of the heart at the completion of pericardial resection. Note how the heart has enlarged from its diaphragmatic 'bed'. (*Case* 2.)

The transpleural exposure is achieved by a submammary incision along the 4th left interspace through muscle down to the rib level. Close to the sternum the costal cartilage above and/or below the selected interspace is divided and after securing the internal mammary vessels the pleural cavity is entered. The opening between the ribs is enlarged by use of a rib-spreader and any adhesions of lung to chest wall or anterior mediastinum are separated (*see Fig.* 268). This approach allows more direct attention to be paid to the left border of the heart, but is not so effective for the anterior surface. In both cases the right side of the heart is not really accessible, and on the rare occasions that this is required a modified exposure will be required.

The heart and pericardium usually present as a more or less solid looking mass, deeper than anticipated and with a limited degree of pulsation. The method of dealing with the actual pericardium has already been indicated, as far as this difficult part of the operation can be discussed in print. On completion of the operation the incision is closed in layers after evacuation of air and fluid from the pleural cavity if this has been opened. Drainage is not necessary, though aspiration of the pleural or extrapleural cavities is required until the spaces are dry.

Complications and Dangers.—Cardiac arrest and hæmorrhage are the outstanding dangers during operation. The heart is surprisingly tolerant of gentle manipulation, though if extrasystoles occur too frequently the heart should be rested for a minute or so; it is continued handling in the face of irregularities that may cause arrest. Even then it is possible to regain the heart beat by a period of rest with careful manual or electrical stimulation of the ventricular muscle. Hæmorrhage from the myocardial surface usually stops spontaneously, but if persistent may require a warm pack or free muscle-graft. Damage to a coronary vessel is best remedied by suture of a muscle-graft over the bleeding piont in preference to application of sutures which may further injure the blood-supply to the myocardium. Gross hæmorrhage is generally the result of opening into one of the heart chambers. The auricle regions are most obvious points of danger, and the wall of the right ventricle is more liable to penetration than the left. Missing the plane of dissection and tearing into heart muscle is where misadventure is most likely to occur, and burrowing plaques of calcium give their own warning. Experience suggests that it is advisable to stop operation if any untoward occurrence is encountered; this is not irretrievable, since the plane of dissection is comparatively easily recovered at a later operation and is not unduly obscured.

Cardiac dilatation and ventricular fibrillation are later dangers to which allusion has been made. Early and complete re-expansion of lung is essential if the pleural cavity has been opened, since a collapsed lung will add to the circulatory load. The dangers of activation of a tuberculous process cannot be ignored, though careful selection and timing of the operation should reduce this complication to a minimum.

The post-operative period is usually uneventful, though the most careful watch for any untoward signs and symptoms must be made. Oxygen is sometimes required, and the continuation of the pre-operative medical treatment in the form of restricted fluid intake and mercurial diuretics should be practised. Recovery may be rapid in the early stages, but there is often a definite lag period over the first two weeks before active improvement sets in. Good symptomatic progress can usually be noted, though the signs are much slower in regression. Where complete recovery occurs the case is probably of relatively short duration, the possibility of liver and visceral damage hindering complete recovery in older and more long-standing cases should be considered.

Effects of Pericardiectomy.—Though an efficient freeing of the ventricles actually restores the pulse pressure to an almost normal level at the time of operation, the venous side of the circulation responds much more slowly. A lowering of the venous pressure and reduction of ascites and liver size may be noted within a few weeks, but full and final improvement should not be expected within twelve to eighteen months. It may be that, though ventricular function is restored and an increased

output from the heart thereby attained, the co-ordinated contraction and elastic recoil of the auricles are not reinstated at the same time and are more slowly compensated.

Rapid amelioration of symptoms is usual, quite out of proportion to decrease in the signs, and the improvement is maintained in practically all cases. The venous pressure, however, often persists at a high level without causing the patient much inconvenience. Functional recovery can be of the order that permits a totally incapacitated patient to return to active physical work sometimes of heavy character, but commonly the duration of the illness has made its mark and the patient though relieved of symptoms is content to, and probably only capable of, leading a quiet existence. The question of interference with liver function has already been mentioned as a possible cause of failure to realize full recovery. Inadequate surgery is the most obvious reason for an imperfect result; great clinical improvement can often result from an apparently minimal clearance of pericardium, but the term 'cure' can critically only be applied to those cases in which the pericardiectomy has been extensive.

Recurrence of the scarring as a possible late sequel should not be excluded, but the type of scar which forms over the excised area is of loose vascular form and is most unlikely to constitute a dense fibrous membrane again.

Figures and Results.—The collected figures for pericardiectomy are sufficient for a preliminary assay of the value of the procedure, but certain factors must be borne in mind when they are reviewed. Of the total 143 cases recorded by Heuer and Stewart (1939) there were only 8 surgeons (7 only checked) who had published a series of more than 5 cases; 27 of the protocols were single efforts and doubtless a great many failures have not been recorded. The results published give an average of over 50 per cent cured or improved, the operative mortality lying in the region of 33 per cent, with about 10 per cent later deaths. Individual series such as those of Blalock (1940), Tudor Edwards, Churchill, and Heuer, as might be expected, give better results, and it is along the lines of considerable experience rather than on individual attempts that the success of the operation will be judged. An assessment of the current literature to which have been added some figures personally contributed by surgeons in this country, including a series of 18 from Tudor Edwards, brings the total up to 227, with a tendency towards reduction of the death-rate and consequent improvement in the final results.

CASE REPORTS

Case 1.—Female, aged 11 years. As a baby the patient suffered from rickets and was in bed for four years. She then remained normal until 10 years old, when pain in the legs developed. Later the child complained of shortness of breath and had to sleep propped up; swelling of the abdomen was also noted.

On Examination.—The child was weakly and undersized. Marked cyanosis was present with dyspnœa and cough on the least exertion. Venous engorgement in the neck and face was well defined, with pulsation considerably raised. Prominent veins were also present over the chest. The area of cardiac dullness extended into the posterior axillary line and 4 cm. to the right of the midline with no pulsation and inaudible heart sounds. B.P. 86/66. Pulse paradoxical, rate 100. The liver was enlarged 4 cm. below right costal margin; there was no ascites or œdema of the legs. Radiologically the huge globular outline of the heart was noted with complete absence of pulsation and some congestion of the lungs. There was a small area of pulmonary infiltration in the right mid-zone.

The diagnosis of chronic tamponade, due to pericardial effusion, was confirmed by aspiration of 30 oz. of straw-coloured fluid (*see Fig.* 266, A). Re-accumulation of fluid was rapid and a further three aspirations, with total removal of over 4½ pints, were performed during the next eight weeks. The fluid was cultured for tubercle bacilli, with negative results; the cellular content showed 99 per cent lymphocytes.

Electrocardiography showed inversion of the T-wave in all leads. Patch test positive for both bovine and human T.B. No significant changes in blood chemistry.

Rapid accumulation of pericardial fluid, with a tendency to tamponade, suggested that a more permanent method of relief other than by aspiration might be attempted—namely, that a pleuropericardial fistula might be made to allow the larger serous surface of the pleural cavity to share in absorption.

Operation (April 23, 1942).—Incision along 4th left interspace anteriorly, with division of 4th costal cartilage. Free pleural sac opened, pericardium massive and immobile. The pericardium was a massive covering to the heart and on incision was over 1 cm. thick. The condition was that of a 'bread and butter' pericarditis with fluid and softening areas between parietal and visceral layers. The parietal area was freely excised over the left border, apex, and diaphragmatic surfaces, but efforts to identify the plane between visceral pericardium and heart muscle were abandoned after several efforts. The heart remained 'silent' with very poor pulsation and no tendency to enlarge. Closure without drainage was effected.

Pathology.—The excised tissue showed an active tuberculous process with fibrin in the process of organization, scattered tubercles, granulation tissue, and Langhan's giant cells, occasionally of very large size.

Progress.—There were no ill effects from interference and clinical improvement was satisfactory. It was, however, realized that failure to remove the complete thickness of the pericardium might necessitate a further operation. Six months later there was still some raised venous pressure and an enlarged liver.

A year after operation venous pulsation was 60 mm. above the level of the auricle. The liver and belly were still enlarged, but cyanosis was absent and the child's intelligence and growth were satisfactory (*see Fig.* 267).

Two years after operation the condition was still improving. The raised venous pressure was barely noticeable, cardiac pulsation was vigorous, and though the liver was still large there were few physical limitations. She could climb 45 stairs without becoming dyspnœic. Kymography showed free movement of the left heart border (maximum lateral movement 2 cm.) but complete immobility on the right (*see Fig.* 266, C). Three and a half years after operation the patient developed a large cold abscess in the thigh, suggesting that the tuberculous process was still active.

Comment.—In this example of tuberculous pericarditis the effusion originally led to gross tamponade, but the process of constriction was not suspected until the time of operation. The effusion was followed by a very rapid cicatrization of the pericardium, and though the tuberculous nature of the condition was suspected, it could not be proved, until the excised pericardium was examined.

Case 2.—Male, aged 43 years. In 1929 the patient suffered from pneumonia followed by a right empyema

requiring drainage. Œdema of the legs developed shortly after this.

The swelling of the legs extended and became brawny in character, and nine years later constrictive pericarditis was diagnosed. Œdema of the legs became worse and ascites developed, but the patient was able to do a certain amount of work.

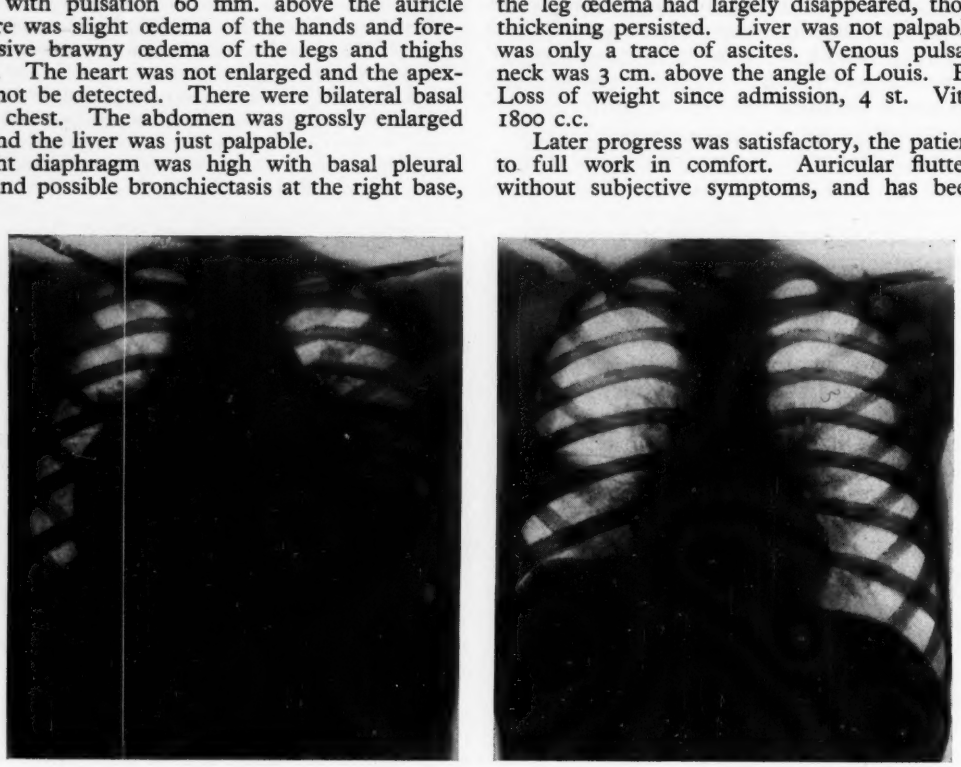
By 1942 there was definite dyspnœa on exertion, with slight cyanosis. The man was heavily built and in reasonable general condition. Venous congestion was noted, with pulsation 60 mm. above the auricle level. There was slight œdema of the hands and forearms. Massive brawny œdema of the legs and thighs was present. The heart was not enlarged and the apex-beat could not be detected. There were bilateral basal rales in the chest. The abdomen was grossly enlarged by ascites and the liver was just palpable.

The right diaphragm was high with basal pleural thickening and possible bronchiectasis at the right base, Suture without drainage. Several periods of rest were required during operation to allow irregular rhythm of the heart to become steady.

The excised tissues showed only extreme fibrosis with heavy collagen fibres (*see Fig.* 265, B).

PROGRESS.—Convalescence was satisfactory and the exaggerated pulsation of the heart subsided within 3 weeks. Paracentesis was continued and mersalyl used in conjunction with a limited fluid intake. The output to intake ratio at one period was 6 to 1. On discharge the leg œdema had largely disappeared, though brawny thickening persisted. Liver was not palpable and there was only a trace of ascites. Venous pulsation in the neck was 3 cm. above the angle of Louis. B.P. 102/80. Loss of weight since admission, 4 st. Vital capacity, 1800 c.c.

Later progress was satisfactory, the patient returning to full work in comfort. Auricular flutter developed without subjective symptoms, and has been observed



A B

FIG. 272.—Radiographic appearances during the development of constrictive pericarditis (*Case* 3). A, Large pericardial effusion. B, Constriction fully developed 18 to 21 months from onset. Heart shadow is obviously smaller. Effusions have disappeared. Ascites controlled by paracentesis.

the heart shadow showed almost complete immobility. B.P. 100/60. Marked pulsus paradoxus. Vital capacity 1100 c.c. Electrocardiography showed moderate voltage. P-R interval 0·2 sec; QRS 0·08 sec. T-wave positive. Sinus arrhythmia. Markedly bifid P-waves in all leads.

Ascitic fluid was pseudochylous, with a fat content between 10 and 60 mg. per cent; proteins 0·5 to 0·7 g. per cent; lymphocytes 86 per cent. Sterile to culture, including T.B.

Abdominal paracentesis was repeated on several occasions (total 24 pints), and a serum transfusion of over a litre was given. Mersalyl injections were started.

Pericardiectomy (April 16, 1942).—Exposure of pericardium after removal of 3rd, 4th, and 5th costal cartilages and part of adjoining sternum. The heart was deeply placed, completely immobile, and stone-like. The covering was firm and whitish, without any calcifications. Incision was followed by rapid and extreme herniation of the heart muscle. The pericardium was $\frac{1}{8}$ in. thick and remarkably tough; it was cleared over the anterior surface of the ventricles, apex, lateral border, and part of the diaphragmatic aspect of the myocardium was freed, (*Fig.* 271). The enlargement of the heart was extreme and the ventricles stood out beyond the level of the skin surface. The pleural cavities were not opened. intermittently. No signs of raised venous pressure now remain, though there is some thickening of the legs.

Comment.—This case of fully developed constriction resulted probably from a suppurative pericarditis following an empyema. Ascites was predominant and the released heart quickly restored this condition. The appearance of auricular flutter after operation should be noted.

Case 3.—Male, aged 11 years. At the age of 8 pain in the left chest, suggestive of pleurisy, preceded signs of pericardial effusion, associated with fever up to 102° F., lasting 5 weeks. Marked tachycardia was present. Pericardial fluid was aspirated. It was sterile and with protein content of 2·5 g.

The child was wasted with a large belly, thin hair, and cold blue extremities. There was dyspnœa on exertion, cyanosis, and slight cough. Veins in the face and neck were congested with venous pulsation more than 10 cm. above the auricle level. The heart apex-beat was impalpable and the sounds barely heard. Pulse 100. B.P. 110 mm. Hg. Pericardial effusion had absorbed and the heart outline was normal in size. There were signs of a right pleural effusion from which fluid was aspirated (sterile and clear). The abdomen was distended with gross ascites and the liver was palpable. There was œdema of the legs.

Radiologically the heart was of normal size, with very diminished pulsation on all borders. A small opacity in the right mid-zone was suggestive of tuberculous infiltration. Patch test was negative and serous fluids and sputum were negative on culture for tubercle bacilli. B.S.R. 2 mm./hour. Circulation time 22 sec. Hb, 102 per cent. Plasma proteins 5 g. per cent. (A/G ratio 1·5/1 per cent.) Ascitic fluid had a protein content of 0·59 g. per cent, chlorides 700 mg per cent.

During a period of observation which lasted over a year and a half from the time the pericardial fluid had absorbed, a left-sided pleural effusion developed. Bed rest and mersalyl injections with frequent abdominal paracentesis produced some improvement, but the venous pressure remained constantly raised.

Pericardiectomy (Jan. 13, 1944).—Exposure of pericardium by removal of 4th, 5th, and 6th left costal cartilages with opening of the pleural cavity. A moderately thick pericardium (4 mm.) was removed from an immobile heart off the anterior, lateral, and inferior aspects of the ventricle (*Fig.* 273). Freeing of the heart displaced the apex ½ in. to the left of its constrictive bed. Condition at the end of the operation was satisfactory.

PROGRESS.—A good recovery followed with a full regular pulse, but suddenly 18 hours later he collapsed and died in 15 minutes. No reason could be advanced beyond an attack of ventricular fibrillation.

Post-mortem examination showed a friable but otherwise normal myocardium. The lungs showed marked brown induration. The abdominal peritoneum was thickened greatly and the liver was enlarged, showing 'nutmeg' changes (*see Fig.* 269).

Microscopy of the pericardial tissue adjacent to the excision showed tuberculous systems amid areas of great fibrosis (*Fig.* 274, A).

Comment.—This case of polyserositis accompanied by constrictive pericarditis was stabilized over a prolonged period to allow the active tuberculous process to become quiescent. No apparent harm was done by conservative treatment and operation was, at the time, well tolerated. The sudden collapse and death probably from ventricular fibrillation was entirely unexpected.

Case 4.—Male, aged 18 years. Accepted A1 for the Services, but within a month complained of shortness of breath and some swelling of the ankles. This was progressive and the œdema extended up the thighs to the scrotum.

ON EXAMINATION.—The youth was large and well built. Engorgement of the neck veins was obvious, with visible venous pulsation above the angle of the jaw. The heart apex-beat, though not strong, was audible and in normal position. There was some ascites and the liver was enlarged 5 cm. below the costal margin. Œdema of the lower extremities rapidly subsided in bed.

Radiology showed a broad upper mediastinum with some congestive markings in the lung fields. On screening the heart pulsation was greatly diminished—a feature confirmed by kymography (*Fig.* 274, A). Vital capacity was 1900 c.c. Electrocardiography showed inverted T-waves and general low-voltage waves. Blood hæmoglobin 98 per cent; white cells 15,000; plasma proteins 5.59 g. per cent. Circulation time 22 sec. No evidence of any tuberculous lesion.

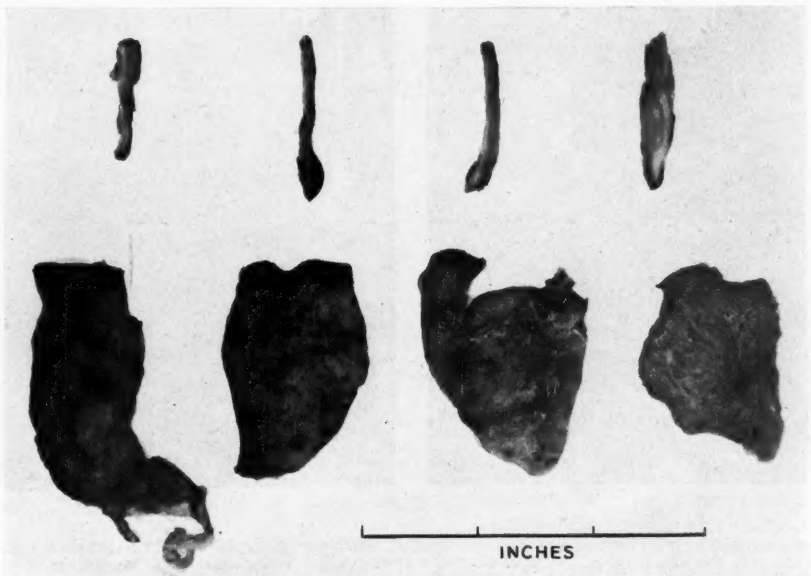


FIG. 273.—Tissue excised at operation of pericardiectomy.

Rapid increase of venous engorgement with appearance of facial œdema suggested progress of the constricting process. Mersalyl injections were started.

Pericardiectomy (Dec. 16, 1943).—Exposure obtained by removal of 3rd, 4th, and 5th costal cartilages, with piece of adjacent rib. The pericardium was whitish, thickened, and immobile. It was incised anteriorly down to heart muscle and dissection of the flaps formed carried to the left border of the heart where the adherent pleura was opened. The pericardium was fibrous and uniformly thick (3–4 mm.). Clearance was made behind the level of the left phrenic nerve, which was dissected free, round the base of the heart off the diaphragmatic attachment, and anteriorly off the ventricles. The heart was irritable during manipulation and did not show any tendency to bulge during the freeing process. It gave the impression of being soft and not restrained.

Microscopy revealed many tuberculous giant-cell systems with epithelioid cells and abundant fibrosis.

PROGRESS.—Convalescence was satisfactory and rapid improvement resulted (*Fig.* 274, B). Within eight months full capacity for exercise and work was achieved with a normal venous pressure.

Comment.—Though the tuberculous nature of this case was not revealed until after operation, it was accompanied by no ill effect. Clinically the diagnosis was

made in the earliest stages and operations carried out in the constricting phase, rather than after full constriction had developed.

Case 5.—Male, aged 48 years. Occupation, chauffeur. History of "influenzal" illness of severe character in childhood. Present disability started two or three years ago with increasing shortness of breath and palpitations. Recent more severe symptoms included tenderness over liver and exhaustion with increasing breathlessness. Slight jaundice on occasions within the last 10–15 years had been noted.

ON EXAMINATION.—General condition was reasonably good, though the man was thin and pale. Cyanosis of the upper extremities, head, and neck was noticeable and exaggerated on lying flat. The veins in these parts were engorged with visible pulsation well above normal limits. Venous pressure by direct measurement was 180 mm. The heart apex-beat was visible 4 in. from the midline in the 5th space. Sounds were audible here and the 2nd sound was reduplicated. Pulse-rate 60, frequent extrasystoles. B.P. 120/74. Liver was enlarged two finger-breadths below the costal margin and was tender. Epigastric veins were unduly prominent (with blood flowing upwards). Evidence of ascites was doubtful.

X-ray examination showed increase in the transverse diameter of the heart with calcification of the pericardium, mainly on the right ventricle and left auricle (*see Fig.* 263). Bilateral pleural thickening was present. On screening cardiac pulsation was grossly diminished. Vital capacity 2750 c.c. Normal blood-count and chemistry. Circulation time (saccharin; arm to tongue) 20 sec. Electrocardiogram showed right axis deviation with negative T wave in Lead III only. No suggestion of tuberculosis.

There was some improvement on bed rest, though signs did not alter.

Pericardiectomy (Dec. 7, 1944).—Exposure made by dividing the 4th costal cartilage and entering the left pleural cavity along a 4-in. interspace incision (*see Fig.* 268). The lung was adherent to pericardium which showed little if any pulsation. Plaques of calcium were palpable in the pericardium, though not noticeable in the ventricle walls. Their main distribution was in the auriculoventricular grooves and over the auricles and great veins.

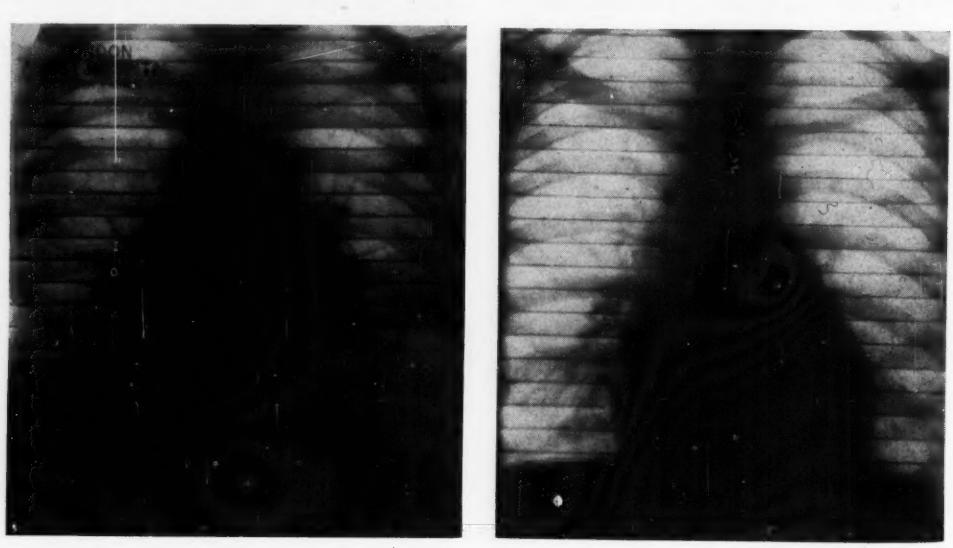
Pericardium was incised and dissected off the heart muscle, not without considerable oozing. It was of variable thickness and the parietal and visceral layers could be separated, so that care had to be taken not to leave the visceral membrane intact on the heart. Dissection was carried round the lateral wall of the left ventricle to the line of the phrenic nerve, over the apex and well on the diaphragm and anteriorly as high as the auriculoventricular groove. No burrowing plaques of calcium were encountered over this operation area. The freed heart pulsated powerfully, but the muscle did not bulge unduly.

Pathological examination of the excised pericardium showed fibrous tissue with polymorph emigration from vessels and some fibrin on the surface. No evidence of tuberculosis.

PROGRESS.—Convalescence was not completely smooth, with bronchitis and multiple extrasystoles as the main complications. Within two and a half weeks recovery was satisfactory.

Ten weeks after operation all symptoms had disappeared. Venous pressure 100 mm. water. B.P. 150/98. Vital capacity 2900 c.c. Forceful impulse of heart with normal sounds. Four months later he returned to full work.

Comment.—Though on the evidence of marked calcification this case was of long-standing duration, the actual constricting process was of limited duration and was treated before it became too gross.



A B

FIG. 274.—Radiographic appearances before and after pericardial resection (*Case* 4). A, Pre-operative kymograph. Pulsation almost completely absent over the whole heart. B, Post-operative kymograph. Reasonable pulsation of the left heart border, slight movement only on the right.

A further 12 cases of constrictive pericarditis have been observed, but have not been submitted to surgery. Seven of these (6 of tuberculous origin) await surgical interference, 1 refused operation, and 2 died, 1 of generalized tuberculosis and the other was in too advanced a condition to consider operation.

In addition 4 autopsy specimens were studied. The cause of death in three instances was almost certainly constrictive pericarditis, unsuspected during life. In the fourth instance an associated cardiac condition of congenital type was responsible for death.

Acknowledgement.—Many of my colleagues have contributed largely to the investigation, study, and care of the patients concerned. To them and their assistants my warm thanks are due. By name I would particularly like to mention Professor G. W. Pickering, who has been unfailing with his advice and experience. In the realm of radiology Drs. L. G. Blair and Franklin Wood have given every assistance, and Dr. M. Pryce has been untiring in pathological investigation. My thanks are also due to Dr. Pagel for providing many specimens of great value. Messrs. A. W. Holder and W. P. Pereira have produced nearly all the illustrations and specimens for this article, while Miss Arnott kindly contributed the half-tone drawing.

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THE LAST 'HATE'

AN ACCOUNT OF THE ABDOMINAL INJURIES OF THE V-1 AND V-2 PHASES OF THE WAR ON BRITAIN AND OF THE SHELLING OF DOVER

BY GORDON GORDON-TAYLOR, C.B., O.B.E., SURGEON REAR-ADMIRAL

DURING the recent war the courtesy of the columns of the BRITISH JOURNAL OF SURGERY has been graciously extended to me on many occasions, and in two numbers a very generous page allowance was vouchsafed for my Bradshaw Lecture of 1942 and a Hunterian Lecture in 1944, both of which dealt with the abdominal injuries of 'total war', more especially those received by civilians during enemy air-attacks on this country; the abdominal injuries inflicted in naval warfare also came under consideration, as well as many of the belly wounds incurred by troops in training that found admission to E.M.S. Hospitals throughout the land. This communication constitutes a final chapter in that story. Of the abdominal injuries received by Army troops in battle I am unqualified to write this war, but the right of admiration cannot be denied me, and gladly I offer my laurel for tribute to those of another Service who have either guided or have performed the 'forward' abdominal surgery of this Armageddon in the lands of three continents and with a measure of success that has steadily waxed through the years of conflict and realized a percentage far exceeding the figures emanating from the first Great War more than a quarter of a century ago.

The following account of certain abdominal injuries received by men, women, and children in a special corner of Britain and produced for the most part by new mechanisms of Hun 'hate' which might be said to 'date' these casualties, perhaps has a historical rather than any profound surgical value. The cases have been collected partly through information tendered me by surgeons aware of my interest in the subject, partly by considerable personal endeavour involving frequent hospital-to-hospital visitation and inquiry. To those who have at all times so readily and gladly aided my efforts I am under an immense debt of obligation.

The total number of abdominal casualties resulting from the last indiscriminate attacks on the south-east corner of England have fortunately not been numerous, and I have notes of only 120 patients submitted to operation. Of 79 cases of intraperitoneal visceral injury produced by *V-1 bombs* (the '*flying bomb*') and submitted to laparotomy 60 patients recovered (76 per cent recovery-rate). Of 13 cases explored, where a hæmoperitoneum was found, but no visceral injury demonstrated, only 1 succumbed.

During the '*rocket-bomb*' period 16 cases of intraperitoneal visceral injury were submitted to operation, of which only 9 recovered (56·2 per cent recovery-rate).

Of the 6 intraperitoneal visceral injuries received during the *shelling of Dover* and operated on, only 1 perished. The figures given here represent intraperitoneal visceral injuries for which operation was possible; cases of 'crush syndrome', retroperitoneal hæmatoma, and non-penetrating wounds of the abdominal wall are not computed.

ABDOMINAL INJURIES DUE TO 'FLYING-BOMBS'

This essay does not purport to be a disquisition on the general characters of injuries produced by the 'flying-bomb', but there seems little doubt that injuries from V-1 bombs proved less severe than from the high-explosive bombs on Britain during the earlier years of the war. The damage to property during the V-1 phase was always greater than damage to people, and most of the casualties were secondary to blast effects on buildings, etc.

All have commented on the infrequency of intra-abdominal injury as the result of V-1 explosions; thus, G. H. McNab (1944) had only 3 cases of intraperitoneal injury in 187 patients treated for V-1 incidents in one hospital, and these were all moribund; R. C. Bell (1944) had no penetration of the abdomen in 259 patients in another institution; Miss M. M. C. Louden (1944) found less

than 1 per cent in over 800 injuries in a hospital in South London. Of the 79 patients in this series with visceral injury submitted to operation 14 had no wound and were suffering from damage inside the belly produced by blast, collapse of buildings, etc. The hideous ingravescent din of the 'buzz-bomb' streaking across the sky was a source of annoyance, threatening, like some three-headed Cerberus, burial, blast, or burn to those below; but it was splintered glass that inflicted many, if not most, of the wounds received during the V-menace. Opinions seem to differ as to the penetrating power of glass, but the evidence of cases collected for this review confirms the opinion recently expressed by Michael Smyth (1944); in our series of cases most of the abdominal viscera have been on occasion damaged by glass—intestine, liver, spleen, the left gastric artery, and the pregnant uterus, etc.

Sex and Age.—Of the 92 cases submitted to laparotomy, 50 were females. There were 16 patients under 17 years of age, 8 of them under 10 years of age, and, in addition, there were 2 fœtuses injured *in utero* that subsequently succumbed; 8 patients were over 65, of whom the eldest, with numerous wounds of the intestine, who died on the operating table, was aged 86. A woman, 'mine hostess' of a tavern, aged 66, recovered from a wound of the cæcum (H. Nockold's case), and a man of 65 from a wound of the duodeno-jejunal flexure and several lacerations of the small gut and the meso-sigmoid (H. W. L. Molesworth). T. Meyrick Thomas and R. A. Kerr each saved the lives of two-year-old children; the former's patient had been buried under the debris of a collapsed house for three hours and had also a small wound over the left lower ribs in the mid-axillary line. The infant was found to have a wound of the stomach and edge of the liver; a small metallic foreign body, half an inch in diameter, was found embedded in the posterior abdominal wall just above the first part of the duodenum. In Kerr's infant the intra-abdominal damage was fortunately confined to the omentum.

Blast Injury.—

Case.—Evelyn R., aged 7, was thrown across a surface shelter by the detonation of a V-1 bomb; she was not thrown against any object which might have caused abdominal injury. There was no loss of consciousness, but there was abdominal pain within an hour, associated with vomiting. Over two pints of blood were found in the peritoneal cavity at laparotomy at Hackney Hospital, but no visceral damage was discernible. Recovery was uneventful (G. Neville Taylor's case).

A curious stroke of fortune directed at various times 5 cases of abdominal injury due to 'buzz-bombs' to the skilful hands of Meyrick Thomas, and 5 patients recovered. The case of the infant of 2 years has already been referred to, but two of his other successful cases were a girl of 9 and a boy 15 years of age. The last was apparently a blast injury of the abdomen:—

Case.—P. T., aged 15, was admitted to hospital in a very shocked condition one hour after a 'flying-bomb' had exploded on his home. He had hæmatemesis and hæmaturia and a considerable hæmoperitoneum was found on laparotomy. No visceral damage was demonstrable except several contusions of the small intestine. No bruising of the anterior abdominal wall was present. The boy had also got a dislocation of the left hip-joint, which was reduced, and a fracture of the pelvis; a lacerated wound of the left calf was also present. A stormy convalescence followed operation; anuria was present for 48 hours, the blood-urea rising to 450 mg. Intravenous drip (blood, plasma, and saline) for 12 days. Ultimate excellent recovery. (T. Meyrick Thomas's case.)

The predilection of the 'flying-bomb' for children as its victims finds corroboration in those injuries which have involved the fœtus *in utero*. One case of this kind where a fœtus received a blast injury of the abdomen from a high-explosive bomb was recorded by the author in his Bradshaw Lecture in 1942. The 2 cases in this series were six- and seven-month pregnancies respectively.

Case.—A woman was admitted to hospital after a V-1 incident with a wound of the right loin through which about half the length of the small gut had protruded and was lying in the patient's clothing. The degree of shock was only moderate, and it was possible to commence operation half-an-hour after the patient's admission, the usual resuscitation measures having been instituted. The wound in the loin, which was 4 in. in length, was excised and prolonged downwards and medially; the peritoneal cavity was full of blood and fæcal matter; the cæcum and terminal 2 in. of the ileum were severely lacerated. On passing his hand into the pelvis, the surgeon felt the legs of the fœtus extruded through a rent on the right posterolateral aspect of the uterus. The fœtus and placenta were quickly delivered through the uterine laceration, the damaged ileocæcal portion of the bowel was resected, the ends anastomosed, and the junction exteriorized. The ragged edges of the uterine laceration were excised and sutured. A piece of metal, 2 in. square, was recovered from the bottom of the pelvis, and another fragment half the size was so firmly driven into the tibia that a chisel had to be used for its extraction; 200,000 units of penicillin were administered, but death took place 56 hours after operation. Post-mortem: the uterus was well contracted and the placental site was clean (F. W. M. Pratt's case).

Case.—Doris R., aged 27, was seven months pregnant when she was involved in a 'doodle-bomb' incident in the South-east of London. She had multiple injuries due to glass, and one glass fragment had penetrated the abdomen and was removed from the cavity of the uterus, which contained a 7-months' child. Laparotomy was performed by Mr. J. L. Stephen, the child was extracted through the rent made by the missile. The mother made a good recovery; the child survived two days.

Laceration of Inferior Vena Cava.—H. A. Kidd's successful suture of a laceration of the inferior vena cava has already been reported in the BRITISH JOURNAL OF SURGERY (1945).

Proximity to Explosion of 'Flying-bomb'.—A woman patient admitted to Charing Cross Hospital actually claimed that a 'flying-bomb' fell on her. She was profoundly shocked, and a deep wound of her right buttock was bleeding profusely. At operation by Mr. R. A. Fitzsimons the buttock wound was dealt with and found to involve the abdominal cavity. Laparotomy revealed the presence of a considerable amount of blood in the cœlom; there was bruising of the lower sigmoid colon and mesosigmoid, and a tear 3 in. long on the left

antero-lateral aspect of the lower sigmoid involving the serous and muscular tunics. The condition of the patient rapidly deteriorated during the operation, which was therefore abruptly terminated. Next day the patient had improved, but equivocal abdominal signs and symptoms and the uncertainty as

FIG. 275.—Left kidney from patient with left-sided abdomino-thoracic injury from fragment of metal from 'flying' bomb. Recovery. (John Everidge's case.)

to visceral damage engendered by the need of the hasty closure of the abdomen the preceding day compelled a fresh intervention. There was more blood in the peritoneal cavity, but despite the bruising and œdema of the lower sigmoid and pelvic rectum, the bowel was obviously viable. No other intra-abdominal lesion was found, and the woman ultimately made a good recovery.

The Predilection of the 'Flying-bomb' for Hospitals.—The affinity of V-1 bombs for hospitals and institutions for the poor and aged equalled its predilection for babes and children. From one metropolitan hospital which endured more than its share of injury from indiscriminate air attack patients who had received abdominal injury were transported to London's most historic hospital; one had been an inmate of the damaged institution for severe heart disease, another had been tied to bed in a plaster carapace after an operation on her hip. One made a good recovery after a splenectomy (Harold Wilson); another under treatment in the first hospital for "a double aortic lesion and coronary insufficiency" was injured by glass in the right side of the belly. A wound in the right loin was found to penetrate the peritoneal cavity, but although there was an amount of blood in the cœlom, no visceral injury was discovered. He made a good recovery. (Rupert Corbett's case.)

A third case from the same damaged hospital had had an arthrodesis of the hip, and was admitted to St. Bartholomew's in a severe state of shock and with a large wound in the left loin just below the left costal margin; half the spleen and fat were protruding. It was only after twenty-four hours' efforts at resuscitation that any thought of operation was possible. As a forlorn hope the wound was explored, and a piece of glass 3 in × 2 in. removed, which had gone through the lower three ribs, diaphragm, and pleura, completely bisecting the spleen. The patient failed to rally from the operation.

The British soldier in the London area did not escape scatheless in the matter of abdominal injury during the 'fly-bomb' period. Such a *rara avis* is reported below.

Case.—An officer was injured in the open, and was admitted to hospital with a large jagged wound below the left 12th rib, and passing pure blood in the urine. X-ray examination revealed a large hæmothorax with some mediastinal displacement and a large foreign body just below the left diaphragm. Aspiration of the chest was performed on two occasions, 35 oz. and 32 oz. of blood being removed. The wound in the loin was excised by Mr. John Everidge; the left kidney was severely lacerated and contained a large metal fragment (*Fig.* 275, Nat. War Coll. 397). There were two holes in the diaphragm, one probably caused by the fractured 12th rib, the other by the missile. Another two pints of blood were removed from the pleural cavity, and the diaphragm was repaired. The pleural cavity was intubated and water-seal drainage established. The lumbar wound was lightly frosted with flavine-sulpha powder, a few sutures were inserted, and also a vaseline gauze drain. The patient made an excellent recovery.

ABDOMINAL INJURIES FROM ANTI-AIRCRAFT FIRE DURING V-1 PHASE

The wonderful achievements of the anti-aircraft gunners against the 'doodle-bombs' from across the Channel and North Sea have now been promulgated, but it would have been idle not to expect some casualties, even abdominal casualties, from "what comes down". Yet I have only notes of 3 abdominal cases during this period. Perhaps the most brilliant result in this type of casualty was obtained by Gerald Townsley, of Rochester, in a warden 68 years of age.

Case.—**Abdominal-thoracic wound; fragment in right ventricle: recovery.**

Isaac M. was on duty when he was hit by a fragment of anti-aircraft shell. On admission to hospital two hours later he was profoundly shocked, of a cyanotic tint, and dyspnœic. There was a penetrating wound in the epigastrium 1½ in. below the ensiform cartilage; tenderness was present in the epigastrium, but there was no rigidity. Clinical examination revealed no abnormal pulmonary or pleural abnormality; the heart-sounds were faint. The radiographs were unsatisfactory, and no foreign body was visualized. After 3 pints of plasma had been administered, operation was performed eight hours after injury. After excising the wound in the epigastrium, the track of the missile was found to proceed upwards through cœlom, diaphragm, and pericardium, which was full of blood-clot. When the clot had been removed a laceration could be seen in the wall of the right ventricle which was oozing. On probing the aperture a fragment of metal was detected; this was removed, more free bleeding from the wound of the heart ensued, which was controlled by suture. The pericardium was not sutured; a piece of corrugated rubber drain was inserted through the wound in the abdominal wall down to the pericardium. The metal fragment measured 1¼ in. × ⅛ in. After operation,

auricular fibrillation continued for three days and then subsided. The man left hospital six weeks after injury; three months after discharge from hospital he was able to perform his ordinary duties, but became somewhat breathless on going up hills.

Another civilian anti-aircraft shell casualty was a right-sided abdomino-thoracic injury associated with a fragment in the wall of the second part of the duodenum. A successful result followed. (H. W. Molesworth.)

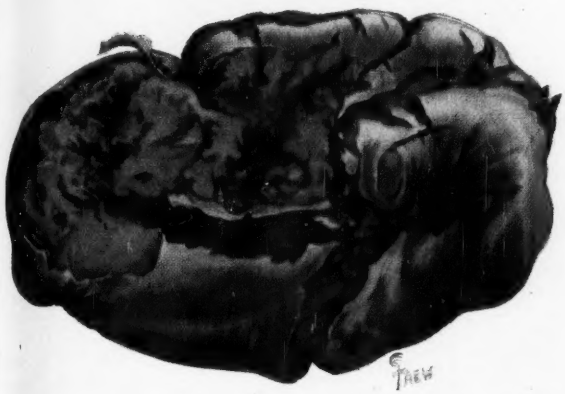

FIG. 276.—Rupture of spleen from collapse of house in close proximity to explosion of 'flying' bomb. Recovery. (H. W. L. Molesworth's case.)

V-2 OR 'ROCKET-BOMBS'

The abdominal injuries received in this country from 'rocket-bombs' were few in number; careful and punctilious inquiry has failed to discover more than 16 abdominal visceral injuries due to V-2 incidents submitted to operation; almost half of these cases were due to crush injuries and associated with fracture of the pelvis and other bones.

Perhaps the first abdominal injury from a 'rocket-bomb' coming to surgery was successfully operated on by T. Meyrick Thomas, whose record of success, apart from his Army service, in dealing with abdominal injuries received by citizens in this country is indeed an enviable one.

Case.—A man was in a tree picking fruit when he was blown up into the air. On admission to hospital he was not shocked and was operated on three hours after injury. A metal fragment had perforated the bladder from before backwards and lodged in the peritoneal cavity; its velocity was only sufficient to damage the sero-muscular tunics of the sigmoid, but enough heat had been retained to burn the gut in two places.

Perhaps the most dramatic type of abdominal injury produced by a 'rocket-bomb' was described to me by John L. Stephen, of Dulwich Hospital.

Case.—A woman of 52 had her abdomen impaled by a rafter beam, when a large fragment of an exploding V-2 passed through the roof of her home. To release the patient from the wreckage under and by which she was pinned, the beam of wood had to be sawn through on each side of the woman's body. On admission to hospital the patient was profoundly shocked. A piece of timber varying in diameter from 2 in. to 3 in. and measuring 2 ft. in length protruded from a jagged hole below the 12th rib in the right lumbar region; its other end projected through another rent in the abdominal wall in the left iliac fossa. The wounds of entry and exit were excised and joined by an oblique incision across the belly in order to lift out the beam. The beam had traversed the peritoneal cavity and passed through the great omentum, but the colon, though badly bruised, was not perforated, and the small gut had not been lacerated. From the cœlom more than 1 lb. of assorted splinters and ceiling plaster was removed. The muscles of the abdominal wall were grossly lacerated and necrotic; there was some bruising of the inferior pole of the right kidney which was exposed at the bottom of the lumbar wound. The patient also presented other severe wounds; one in the lower part of the right side of the neck exposed the subclavian artery and vein; another wound across the right wrist had severed radial and ulnar arteries, while from a laceration in the left groin a jagged piece of wood has passed down along Hunter's canal almost to the knee, fortunately without damaging the femoral vessels. The patient's convalescence was reasonably smooth and the large irregular abdominal wound healed soundly without suppuration or the development of a hernia (*Fig.* 277).

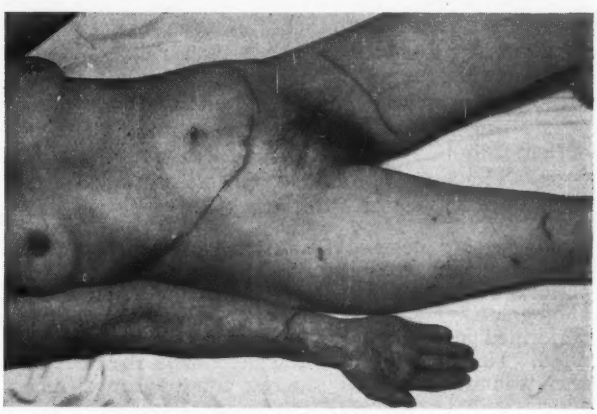

FIG. 277.—Photograph of patient whose abdomen was impaled and transfixed by a piece of timber in rocket-bomb explosion, depicting the length of the wound excision and the final state of repair. (J. L. Stephen's case.)

Another dramatic case was that of a railwayman crushed between two railway trucks at the moment of a 'rocket incident'. This was a magnificent result in the hands of Desmond Cooper, for the patient recovered from a resection of 8 ft. of small intestine and the suture of another laceration. In addition, the man had sustained a disruption of the symphysis pubis and a fracture-dislocation of the right sacro-iliac joint.

A little girl of 12 years of age under the care of J. T. Laurenson recovered from multiple injuries due to a 'rocket incident', which included a separation of the mesosigmoid from the bowel for a distance of 5 in. or 6 in.; the colon was already becoming gangrenous at operation. Recovery followed an exteriorization technique.

A woman recovered in St. Bartholomew's Hospital from multiple injuries due to a V-2 explosion on March 8, 1945. An enormous bomb fragment, measuring 4 in. × 6 in., was removed from the right hypochondrium; the 8th and 9th ribs were shattered, and liver, gall-bladder, and colon were herniated through the wound. Ultimately an excellent recovery followed. (Case of Harold Wilson.)

Very severe damage to the liver is compatible with survival. In the last war recovery followed

wounds where portions of the liver were found free in the cœlom. One such case due to a 'rocket-bomb' was successfully operated on by W. E. Joseph, of Whipps Cross Hospital. A fragment of liver, 3 in × 2 in. × 1½ in. had been avulsed from the liver mesial to the gall-bladder; the boy of 15 recovered.

More rarely organs such as ovaries and Fallopian tubes have been damaged and successfully treated along with other injuries. (Case of S. H. Wass.)

ABDOMINAL INJURIES DUE TO SHELL-FIRE ON DOVER

A soldier belonging to the Army of a great Ally, a G.I., E.T.O.U.S.A., while visiting Dover during the period of shelling from the guns at Cap Gris-Nez, and while happily and eagerly with some girl-friends seeing the sights, doubtless hand-in-hand—*O felicitas curiosa!*—received multiple injuries from an exploding shell, a fragment of which penetrated his abdomen, producing wounds of anterior and posterior surfaces of the stomach; there was much blood in the peritoneal cavity. Clinical evidence of acute intestinal obstruction necessitated a second laparotomy on the twelfth day after wounding; a coil of jejunum had attached itself firmly to the pelvic floor. The loop of gut was freed and subsequent convalescence was uninterrupted. (T. J. Cobbe's case.)

Case.—A woman in a Church Army hut had a shell explode at her feet. The devastating character of her perineal injuries may be gauged from the accompanying photograph (*Fig.* 278). An inguinal colostomy was performed and suprapubic drainage of the bladder instituted. Her recovery was despaired of in the early days after wounding, but her progress towards convalescence appeared to be materially influenced by the initiation of penicillin therapy. Her bladder sphincter had fortunately escaped damage, and sphincter control of her rectum

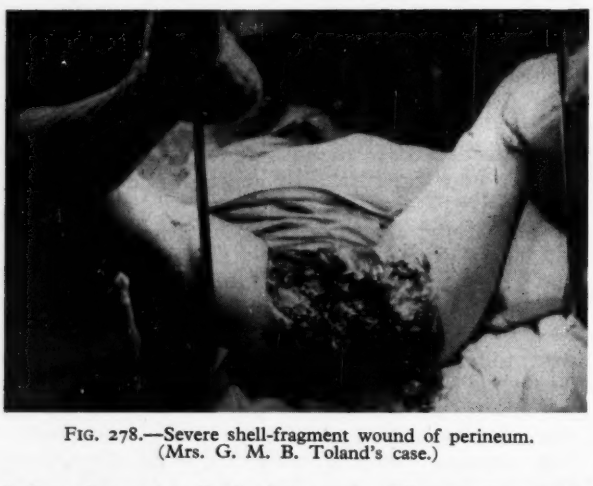

FIG. 278.—Severe shell-fragment wound of perineum. (Mrs. G. M. B. Toland's case.)

had not been completely destroyed. The province of the plastic surgeon has no territorial limits; his skill in repairing the ravages of war even in the less conspicuous regions of the body equals that which he has manifested so signally in the restoration of facio-maxillary mutilations or of damaged or burnt extremities. Of him it may often be said:—

> "And ne'er did Grecian chisel chase
> A Nymph, a Naiad, or a Grace
> Of fairer form or lovelier face."

My colleague, Rainsford Mowlem, has effected a miracle of repair in this *grande blessée* (*Fig.* 279). (Mrs. G. M. B. Toland's case.)

FIG. 279.—Same case. Wound of perineum in process of repair; the "reconstructed vaginal and anal orifices are reasonably well shown". (*By courtesy of Rainsford Mowlem.*)

Another casualty had suffered a mutilating, lacerated wound of the right flank which had involved the crest of the iliac bone, the glutei, and muscles of the abdominal parietes, and had laid bare a lacerated cæcum and ascending colon in the depths of the carnage. When seen by the Receiving Medical Officer, he said: "Don't bother about me. You get on with the others. I shan't live through this at my age."

Blood transfusion was started and he was taken to the theatre at 4.35 a.m. Hæmorrhage was arrested, and such toilet of the wound performed as his condition permitted. A Paul's tube was tied into the exteriorized cæcum. True to his own prophecy, he died three hours after operation.

Case.—Emily A., aged 36, was admitted to Dover Hospital on Sept. 25, 1944, as a casullty from enemy shelling. There were two lacerations involving the peritoneal cavity, evidently entry and exit wounds, each about 3 in. in length, and situated in the upper left abdomen. Through the anterior wound the liver and everted stomach could be seen; through the posterior rent the colon was protruding. There were also numerous punctured wounds of both legs, one producing a fracture of the left fibula; a wound of the right buttock had a retained shell fragment; there was also a laceration of the neck. The pulse-rate was 134; the blood-pressure was unrecordable. At operation, performed three and a half hours after wounding, when 4 pints of blood had enabled a systolic blood-pressure of 100 mm. to be registered, several lengthy vertical fissures of the liver were found, which were sutured with catgut. The spleen was pulped and was removed; a partial detachment of the diaphragm from the costal outlet was repaired; but *the extraordinary lesion* was that of the *stomach*, which was rent from near the cardia to the pylorus for a length of at least 6 in., *the viscus being*

turned inside out. The gastric laceration was responsible for most of the bleeding which had taken place and was still continuing at the operation. The gastric contents had been poured out under the diaphragm—an eloquent reminder of food-rationing and the value of 'allotments'; carrot and cabbage were hastily scooped out; the everted stomach was restored to anatomical normality of shape, and the lengthy tear was sutured in two layers.

A left-sided pleural effusion required aspiration, but the patient ultimately made an excellent recovery. (G. Gordon-Taylor's case.)

SUMMARY

1. The abdominal injuries received during the V-1 and V-2 phases of the war on Britain and during the protracted shelling of Dover were *not* numerous.

2. The recovery-rate of proved abdominal visceral injuries due to 'flying-bombs' and treated by laparotomy was no less than 76 per cent.

3. The recovery-rate of the abdominal visceral injuries due to 'rocket-bombs' was 56·6 per cent, and of the few Dover casualties 83 per cent.

This paper could not have been written without the loyal and ungrudging help of the surgeons of that South-east 'bit' of England, including the London area. The inescapable anxieties of an environment in which surgeons, men and women, of every age have laboured so loyally and devotedly and with such conspicuous success during more war years than the period under review prompt these lines written two thousand years ago as applicable to their philosophy and spirit.

"*Dum loquimur, fugerit invida*
aetas : carpe diem, quam minimum credula postero."
(Horace, *Odes* I–II.)

; "each word we say,
Some envious moment melts away,
Trust nothing to the morrow, live to-day."

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THE GERMAN HOSPITAL CENTRE AT ABANO TERME

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SURGEON AND ANÆSTHETIST WITH A FIELD SURGICAL UNIT, CENTRAL MEDITERRANEAN FORCE

AFTER the cessation of hostilities in May, 1945, instructions were received to act as Surgical Adviser to the British Cadre appointed to administer a collection of German Field Hospitals taken over by the Eighth Army.

The patients were grouped in thirteen scattered hotel buildings in the spa town of Abano Terme, North Italy, the area having been used as a medical centre for the previous eight months.

Contrary to expectation, the conditions of hygiene, nursing, and surgical treatment were found on arrival to be extremely unsatisfactory and well below British standards; and so bad were they that it is considered that an account of both these and the action taken to improve them is worthy of record.

In order to present a fair picture an attempt has been made to outline the official German surgical policy and to contrast this with the clinical evidence available, records of fatal cases, and, when necessary, with corresponding British methods and the evolution of these since the period before Alamein.

This report on conditions and the action taken for their improvement has been subdivided under the following headings: (1) General hospital hygiene; (2) Asepsis, antisepsis, and nursing; (3) Surgical clinical survey; (4) Blood transfusion and penicillin therapy; (5) Survey of medicine, anæsthetic, and V.D.; (6) Analysis of deaths in hospital; (7) Summary of standard German methods in war surgery; (8) Discussion.

GENERAL HOSPITAL HYGIENE

The hospital area as a whole had approximately 2500 available beds, of which a varying number in the region of 2000 were occupied. A tour of inspection of the individual buildings revealed that certain of these were more suited to nursing and operative treatment than others. Overcrowding and cross-infection were accompanied by inadequate grouping of the cases.

The hospital organization was based on a number of individual field hospitals, each with its own independent administration, and accordingly cases of all types were intermingled in each hospital. An odour of stale pus hung round most of the wards and corridors, and the patients in these lay, thin and waxy-pale, varyingly crowded together, on "scruffy" beds of every size and shape. In some buildings more effort had been made to improve the hygiene and asepsis, and one was immediately struck by the different atmosphere and the fact that the wounds in these wards were usually healing cleanly. Bed-bugs and lice were not common. The condition of the bedding was good, but an unnecessary quantity of furniture congested the wards. Water was plentiful, as the spa town is centred on a number of hot springs, and most buildings were fortunate in possessing a constant supply of hot and cold water from their taps. The 'natural' waters were said to contain iron and sulphur, and it was found that one scoopful of W.S.P. per 100 gallons was required to render it drinkable.

Attention was first directed to improving general ventilation and removing all unnecessary furniture from the overcrowded rooms and corridors. The bed state of each building was reviewed, 1000 cubic feet being adopted as a minimum standard for each bed. At the same time, sites were selected for the establishment of special centres for certain groups of cases, their situation depending on the requirements of the different groups and the suitability of the various buildings. This reorganization was carried out with the aid of a series of clinical survey forms, one from each building, to be described below. Wherever possible the most seriously ill patients were placed under the best conditions, and lighter cases were transferred by ambulance to the less pleasing available accommodation.

Every building had electric light and good water sanitation.

ASEPSIS, ANTISEPSIS, AND NURSING

The standard of asepsis was fair in one or two buildings, but very low in many. This was due to a combination of factors. First, a gradual lowering of aseptic discipline induced by the Italian and the severe Russian campaigns; second, a recent period of overwork associated with defeat; third, inadequate forward surgery; and fourth, poor treatment and nursing since arrival at Abano.

Sepsis was evident at every turn. Many cases had reached the hospital with already septic wounds, their sepsis being largely attributable to inadequate forward wound excision, even when allowance is made for the delays due to the harassing of lines of evacuation. Cross-infection must have been the primary cause in many, and reinfection at the time of subsequent operation or dressing in others. Most dressings were carried out in a way which compared unfavourably with the methods one might adopt in a crowded casualty or M.I. room under difficult conditions. Bandages and dirty dressings were removed and re-applied with the fingers, and washing of the attendants' hands and forearms, and the use of sterilized instruments or bowls for major dressings had largely been dispensed with. Masks and theatre gowns were not worn, and sterile towels were noticeable only by their absence. In one theatre we entered, the floor was being swept with a broom while an operation was in progress, and in another an autopsy was being carried out. Most theatres had no sterile drums or dressings. Shaving, soap and water toilet, and skin preparation were inadequate. Instruments were boiled, but were sometimes laid out on non-sterile paper sheets. One doctor, indeed, was seen to put apparently sterile gloves on to unsterile hands. Cases of all degrees of sepsis were treated side by side in the same theatre.

It was first decided that each building must have two theatres. In one the dressings of all septic cases fit to be brought from the ward were changed, and grossly septic operations performed. In the other, redressing of clean cases and aseptic operations could be undertaken. Orders were given for the wearing of masks and a general tightening up of aseptic practice in both theatres and wards.

At the same time cross-infection was reduced by a re-distribution of cases as described in the next section. It was found, for instance, that nearly one-third of all wounds, including even minor cases, had sepsis and fever for more than four days, and orthopædic cases were being treated side by side with septic chest wounds. In fracture cases the œdematous and granulating wounds were reached through windows in the plaster-of-Paris casts. When copious pus was flowing, a bowl could be found beneath the window to collect it, and a swarm of contented flies completed a pre-Listerian picture.

The treatment of these septic wounds had been by applications of rivanol or sulphonamide and by water compresses applied at two- or three-day intervals. The policy now adopted was one of daily dressings with Dakin's solution under clean conditions, followed by the application as soon as possible of closed split padded plaster casts. Secondary suture was obviously not yet practicable. Deep wounds were irrigated with eusol through rubber tubes introduced deeply.

There appeared to be no central nursing organization and the nursing appeared in general haphazard. Temperature charts, however, were well kept, and the nursing approach to the patient was satisfactory, although of an unskilled, 'field' type. There were some 200 nursing orderlies, but only 20 available trained German nursing sisters.

There were 4130 sheets, mostly of poor quality. The washing and allocation of these was not well controlled, thus causing a relative shortage among the more severe cases. Soap, towels, and crockery were all scarce.

Beds were fairly evenly divided into three types: wooden hotel beds, iron hospital-type beds, and divans. These, too, were badly distributed as between severe and slight cases.

Bed patients were ill washed; beards and long hair were much in evidence, and bed-sores commoner than is usual.

The nursing staff was reorganized with the aid of a senior sister chosen to carry out duties in the wards comparable with those of an assistant matron. The available skilled nurses and orderlies were directed towards those centres where they were most needed, and a personal tour of every room in every building was made in company with our nursing adviser to ensure that the available space was used to the best advantage.

About 70 per cent of the beds were classed as 'good', and these were redistributed as most needed among the severer cases. Wherever possible a clear floor-space was made round the sides and bottom of each bed.

Instructions were given in each block for the collection of personal equipment into a pack store, as it was found that it was causing unnecessary congestion and collecting dust.

The theatre methods, their siting, and their equipment, were redirected with a view to approaching British standards of asepsis.

The method of distribution of food was examined.

Efforts were made to obtain crutches and fracture-boards, and such articles as toothbrushes, nail brushes, shaving soap, blades, and so on.

Finally, application was made to higher authority for the supply of further skilled nursing staff.

CLINICAL SURVEY

The hospital centre consisted of a series of field hospitals which worked and were supplied for all practical purposes, independently of each other. Each hospital admitted any type of case except head injuries and maxillo-facial, eye, and E.N.T. cases, which were grouped in one hospital. Operating and X-ray equipment were satisfactory.

To assist the control of future policy, it was necessary to re-group the patients according to their clinical diagnoses and state of sepsis. It was considered that this would also lessen the chances of cross-infection and enable the available theatre and special equipment to be used to the best advantage. When a tour of the patients and individual blocks had been made it became evident that certain blocks were suitable only for the treatment of light cases, as they were dark and ill ventilated, having narrow corridors and small rooms. Other buildings were of more recent construction, with large rooms suitable for wards, wide corridors, good hygiene, and good water supply. The policy adopted, therefore, was to make each building into a centre for a particular type of patient, sending the light cases to one, chest cases to another, amputations to another, and soon. Information had also been received that evacuation was likely to be stopped soon, and that a further thousand admissions might be expected. A reception centre in a hotel building at the entrance to the area was therefor established.

It became evident that many patients suffering from the effects of chronic sepsis would require blood transfusion and penicillin to save their lives. A clinical survey form was prepared, showing in twelve columns the important facts relating to each class of patient. Classification was by both patients and lesions. With the aid of this record we were able to pick out rapidly the light cases (R.T.U. in 3 weeks), those liable to need penicillin (septic wounds with over 4 days' fever), those requiring blood transfusion, and so on. The 'general post' necessitated by the unification of the hospital group was thus greatly facilitated.

This consolidated form gave a broad picture of the sickness state of the hospital group at the time. There were, for example, 62 patients with wounds involving the dura mater, 181 lower-limb amputations, 87 penetrating chest wounds, 55 fractured femurs, and 50 wounds involving the knee-joint. Some 368 had had fever for over 4 days with septic wounds, 15 had bed-sores, and 177 were classed as dangerously ill and unfit to be moved.

We were now in a position to discuss the relative value of various surgical treatments with individuals, and to know that the result would equally affect a number of similar cases.

At this time the deaths were numbering 3 to 9 each day. Our aims, therefore, were, first, to obtain without delay a clear view of both the orthodox and the actual German surgical policy in any particular class of case; secondly, in the light of this knowledge to anticipate any persistent errors and their consequences.

Accordingly the most experienced German surgeon was requested to write for us a brief account of German war surgical practice. At the same time, we compiled with the aid of our German doctor interpreters, brief summaries of all the fatal cases of the month.

The same surgeon was appointed to act in a position similar to that of a British O.C. Surgical Division, and to give effect to such clinical instructions as were issued by us from time to time.

British Field Medical Cards were initiated with short digests of the German notes for :—

1. All patients about to be evacuated to British hospitals.
2. All patients who received penicillin.
3. All patients likely to be repatriated with serious permanent disabilities.

Daily ward rounds were made, and the following clinical observations arise from them :—

Flesh Wounds.—These had been, as a rule, inadequately excised. Some healed by granulation. In others there was 'phlegmon' followed by abscess formation, and this had been treated by incision and drainage. The drain was usually left in too long, causing excessive granulation and delayed healing. Our policy was that of daily eusol dressings until clean, to be followed when possible by either secondary suture of skin-grafting, with the aid of penicillin if available.

Amputations.—Guillotine operations had almost invariable been performed. A healing period might be hoped for from these lasting 6–8 weeks, if granulation and epithelialization proceeded normally. Definitive re-amputation, with delayed suture if this was considered necessary, could be carried out some three or four months after wounding.

Most of them, however, did not run so smooth a course. A spread of infection to the knee-joint or along the femur, with femoral, pelvic, or even renal thrombophlebitis followed frequently, and re-amputation was sometimes done in an attempt to prevent this. The tying of veins to prevent the spread of thrombophlebitis was fairly frequently carried out. Our policy aimed at the performance of an elective amputation as early as possible, through a penicillin screen with delayed suture and drainage. All wounds were given a course of daily eusol dressings to clear up the gross sepsis before this could be attempted.

Orthopædic Cases.—Limb plasters were on the whole inefficient, and failed to allow good finger and toe movements. Abduction plasters were satisfactory, but above-knee casts were too short and below-knee casts too high.

It was the German custom to transport femur cases after primary wound excision in hip spica, and some were still being treated in hospital by this method. Others were being treated by the normal Base method of sliding traction in bed with a Braun splint and a Kirschner wire applied through the tibia. This method was encouraged after the cases were removed to the fracture centre.

Penetrating knee-joint wounds were normally treated by a hip spica, the joint being aspirated at the Base. When severe sepsis appeared, joint excision was carried out, the upper end of the tibia and the lower end of the femur being resected and the wound being left to drain through a windowed plaster applied from the toes to the umbilicus. This operation in the face of sepsis resulted usually

in osteomyelitis of the femur and tibia, and death was liable to follow unless amputation was undertaken, owing to the spread of sepsis.

Plasters applied to fractures were nearly always windowed in one or more places, and invariable unsplit.

Healing of wounds with fractures was by granulation. Primary, delayed, or secondary suture was not attempted, and had, in fact, been forbidden by the German medical authorities. The period of disability was consequently a long one.

Stiff limbs and venous stasis with thrombosis were associated with a backward attitude towards physiotherapy.

Cranial Surgery.—This was adequately carried out by the neurosurgical specialist under good aseptic conditions. The time-lag of fresh cases had varied considerably. In early cases the policy adopted had been excision of the wound, using a sucker and methods similar to our own, with primary suture, and the results were satisfactory. The older cases had been treated by a modified excision without closure. The wounds were encouraged to granulate from below, and this was assisted by the placing of a small sterile sponge in the wound. When, later, penicillin was given, it was applied either locally, intrathecally, intramuscularly, or by a combination of these methods. It is too early at present for any estimate to be made of the results of penicillin in these late cases.

Chest Surgery.—Primary closure of sucking wounds with excision was the usual policy. Non-sucking wounds were excised, left open, and allowed to heal by granulation. Early aspiration was usually possible, but nearly every penetrating chest wound resulted in an empyema. This was treated by aspiration. When aspirations became difficult, an intercostal space drainage by the Bülau tube method was usually adopted. This was frequently inadequate, and the continuous prolonged pyrexia which followed called for rib resection or thoracotomy. A number of cases had died of septic toxæmia through the neglect of these more radical measures.

It was therefore arranged, in consultation with Brigadiers Boland and Stammers, that all chest wounds should come under the care of one surgeon who had experience of chest surgery. Penicillin was instilled at the time of aspiration into cavities which were suitable. A separate theatre was prepared, and all necessary chest operations were carried out as soon as possible.

The standard of treatment of penetrating chest wounds before this could be classed as ' bad '.

Abdominal Surgery.—There were fewer abdominal cases than might have been expected, mainly because abdominal cases were usually operated on in the German field ambulances and forward hospitals, and were not evacuated from these until fit to travel.

These cases were treated in general on lines similar to our own, except that the wounded colon was commonly sutured and replaced. Infusion, transfusion, and gastric suction were rare; and *either* suprapubic cystostomy *or* an indwelling urethral catheter was used to drain the bladder.

Progress.—The number of admissions and discharges varied, there being any number up to 50 of either on any one day. Seven weeks after the end of April (on June 16), although there were 1440 surgical patients, of whom 1062 had clean wounds and no fever, there were still 252 who had septic wounds and had had fever during the previous four days. These included, correspondingly, fractured femurs (54 and 13), penetrating knee-joints (54 and 18), lower-limb amputations (159 and 39), penetrating brain wounds (43 and 4), and penetrating chest wounds (48 and 41). There were still 120 who required blood transfusion and 78 and 35 patients were now classed as dangerously and seriously ill respectively. There were 560 cases which were considered only fit to be moved within the hospital area, 242 were expected to return to duty within 3 weeks, and 525 within 2 months.

By the end of the June quarter 117 re-amputations, 48 secondary sutures, and 17 skin-grafts had been performed, and 868 patients had been returned to duty. A total of 315 had been classified as suitable for repatriation under the international standard.

It is not possible to offer a fair or scientific comparison between German and British War Surgery entirely on the results seen at Abano Terme, but the following observations are put forward without comment. Simple wounds treated successfully by delayed suture are as a rule healed within 3 weeks of the time of wounding and those by secondary suture within 5 weeks. In one series (Parish) totalling 3845 flesh wounds treated by delayed suture (2693) and secondary suture (276) at 20 different general hospitals in the C.M.F. during September–October, 1944, 90 to 100 per cent healing was recorded in 78 per cent and 67 per cent of the wounds respectively. Another series (Macdougall) of 43 amputations at a similar period gave with delayed suture 87 per cent and with secondary suture 50 per cent successes on similar standards. A mortality-rate of 2·7 per cent and an amputation-rate of 3·7 per cent were recorded in a third series (Furlong) of 218 compound fractured femurs, and in one group of these, numbering 38, treated by intramuscular penicillin and complete suture, 53 per cent were completely healed and 87 per cent had " bone shut off " after eight weeks.

In North Africa, before penicillin was available, an empyema rate of 33 per cent in hæmothoraces was recorded (Nicholson) and a control series of fractured femurs treated in the C.M.F. without penicillin gave an amputation-rate of 8·5 per cent and a mortality of 8·5 per cent.

BLOOD TRANSFUSION AND PENICILLIN THERAPY

Blood Transfusion (in collaboration with Capt. Borrowman of the Blood Transfusion Service).—Cases were selected for transfusion on their clinical appearance, general state of nutrition, and toxæmia, checked by a hæmoglobin and red-cell estimation. Equipment and facilities for the copper sulphate plasma-protein method were not available at first, but were obtained later.

A preliminary survey on this basis showed that there were 497 cases requiring transfusion, of which 224 were below 60 per cent Hb, and since the

majority of these would require 3 to 4 bottles each it was estimated that 800 to 900 bottles would be needed during May.

Blood transfusion had previously been given by the German Staff by the direct arm-to-arm method, and in small quantities (200–250 c.c.). It was considered that this method was too slow, and, in view of the numbers to be treated, arrangements were made for a field transfusion unit to undertake the instruction of the German Staff in the indirect method, using British equipment.

The sources of blood that were available were P.o.W.s' in transit at 373 P.o.W. Camp, north of Mestre, and the German Staff at Abano. It was decided to obtain as much blood as possible from the prisoners while this source lasted, and to use the local staff as a reserve.

German officers and men were selected to form a Hospital Blood Service and demonstrations were given in grouping, and taking and giving blood by our methods. A team of bleeders was formed and was transported to the P.o.W. Camp on the days donors were available to bleed.

Donors were selected from men between the age of 20 and 30 who had no history of malaria, jaundice, or V.D. The group stamped on the identification disc was checked before bleeding, and cross-matching was done before transfusion. All groups were used. No cases of mismatching were reported. The blood taken was held in a hospital refrigerator under the charge of an officer who was also responsible for the general supervision of the Service. A team of givers carried out the treatment in the various hospitals.

From May 14 to 31, 1945, 923 bottles of blood were collected and 801 bottles were given, leaving a stock of 122 bottles in hand. The percentage of the different groups given were A 42 per cent, B 10 per cent, O 44 per cent, AB 4 per cent, and during June a further 801 bottles were collected, of which 789 were given.

A large number of the cases showed evidence of chronic sepsis with pyrexia, yet in only 44 cases were reactions noted: 26 cases had a rigor, 4 developed urticaria, 1 had hæmaturia, and 5 showed mild circulatory disturbance. No jaundice or anuria were reported. No deaths occurred.

During May the blood was used at an average rate of 45 bottles a day and at an average age of 2 days; 344 transfusions were repeated. During June the average was 26 bottles a day, with 637 repeat transfusions. Some of these were given before, during, and after operations.

The results as judged by the improvement in clinical condition were very satisfactory.

Hæmoglobin and R.B.C. estimations were carried out on a series of 46 cases with Hb below 70 per cent and the following results were obtained :—

Average reading before transfusion					2,900,000	R.B.C.,	57·7	per cent Hb
"	"	after	4	bottles	3,500,000	R.B.C.,	77	" " Hb
"	"	"	6	"	3,900,000	R.B.C.,	79	" " Hb
"	"	"	8	"	4,100,000	R.B.C.,	81	" " Hb

The usual interval between doses of 500 c.c. was 4 days.

Penicillin Therapy.—The group of cases in Abano presented us with an unrivalled picture of sepsis in war surgery. It became clear very early that here was an ideal opportunity for research in the treatment of this type of case. Penicillin was required urgently for treatment all over Italy, but permission was granted after a short delay for penicillin to be used on German P.o.W.'s when it was necessary to save life. (Penicillin was also allowed for some sulphonamide-resistant or salvarsan-sensitive cases of V.D., for economic reasons.)

Surgical cases chosen for penicillin treatment were examined personally by us, and were all suffering from prolonged and severe sepsis with pyrexia. The ruling was made that all necessary surgical operative treatment must have already been performed, and that blood transfusion must have been carried out wherever necessary before penicillin was started, the supply of blood, under the supervision of the transfusion unit, being now plentiful.

The usual precautions were observed in the matters of supply and safe storage, but bacteriological control was not possible until the later arrival of Major Scott-Thomson. In consultation with him we were then able to choose cases of chronic sepsis for penicillin not only for the purpose of life saving, but also for research into the action of penicillin on these cases by varying methods.

Bacteriology and the supply of penicillin were now undertaken by the penicillin team. A further report of these investigations will be made at a later date.

Our policy was to use massive doses on a small number of cases and to determine whether they could so control the sepsis that definitive surgical measures could be undertaken. Penicillin was given by intramuscular injection, by local irrigation, and by deep local injection down to the site of fracture using a long needle.

Secondary suture, re-amputation, and early skin-grafting were encouraged, and the German surgeons instructed in the use of penicillin and methods such as the tube technique. Local application of solution or powder was made the procedure of choice, with additional parenteral penicillin when necessary.

SURVEY OF MEDICINE, ANÆSTHETICS, AND V.D.

Medicine.—Apart from the question of tuberculosis, the medical side presented no problem comparable with those of the surgical. There were some 350 medical patients on our arrival, including cases of tuberculosis, convalescent infectious disease, nephritis, infective hepatitis, rheumatism, undulant fever, recurrent malaria, skin diseases, and " minor sick ".

Clinical diagnostic methods were thorough, and records were meticulously kept. The loss of the German mobile bacteriological laboratory, which had been sent away shortly before the end of hostilities, was a handicap, but clinical side-rooms undertook routine examinations of blood, urine, and sputum.

Treatment, though tinged with the academic, appeared sound and well carried out. A rigid and well-controlled Vollhard diet, for instance, was the rule in cases of nephritis. The scheme of malarial treatment approximated very closely to the current British scheme, except for the preliminary quinine.

Skin cases were treated on familiar lines. It was interesting to note the same mental resistance to the conception of sulphonamide dermatitis as is still encountered in the British medical services.

The empirical treatment of the rheumatic group of diseases was given local colour by occasional mud baths and immersion in the spring waters of Abano.

Sulphonamides were prescribed orally with discretion and common sense.

Strophanthin was a favourite drug which tended to appear on charts whenever pulse-rates rose rapidly from any cause. Polypharmacy, however, was less in evidence here than on the surgical side, where it ranged unfettered and unquestioned, reaching its full fury as the patient neared his end under a broadside of coramine, adrenaline, strophanthin, calcium, caffeine, tutofusin, and eupaverin. "Trotz starker Kreislaufmittel tritt der exitus letalis ein" is the routine description of this process.

Tuberculosis.—Owing to recent admissions there were 84 tuberculous patients in the hospital centre. Of these 50 per cent were considered moribund by the German medical officers in charge of them, but we regarded this as too pessimistic an estimate, given reasonably good conditions for their treatment.

Unfortunately the heat and steam of the ubiquitous sulphur springs of Abano Terme provided a very unfavourable climate for the treatment of tuberculous patients in the summer, and the block which we had set aside provided poor accommodation for them. There were two cool airy wards with room for 20 beds apiece, and the rest had to be lodged in small and often stuffy hotel bedrooms. A more suitable building was being sought for them, in the neighbouring hills, so far without success.

Most of the worst cases were Russians, primitive in their outlook and habits, and unwilling to co-operate in their treatment with their German medical attendants. There were also some 25 Serbs, who had been treated with obvious efficiency for several months in German hospitals in Vienna and Laibach.

We obtained a pneumothorax apparatus from an Italian civilian sanatorium in Padova, and the X-ray apparatus was adequate. Some 10 of the patients had "A.P.'s" already established.

Venereal Disease.—On our arrival the V.D. department contained approximately 34 cases of syphilis, 22 cases of gonorrhœa, and 3 or 4 of soft sore.

Syphilis was treated by standard arsenical methods, efficiently controlled by Wassermann and Kahn tests.

Treatment of gonorrhœa was not satisfactory, the rate of primary cure being estimated by the Germans as 35 per cent. This was probably due to the fact that the standard 3-day course of treatment consisted of a preliminary artificial pyrexia produced by olobinthin or pyrifer, followed by a total of 18 g. only of sulphathiazole. Of the 22 cases 17 were in various stages of sulphonamide resistance. These were rapidly cleared by the standard penicillin course of 100,000 units.

An antisyphilitic course of penicillin had also been initiated in two cases of generalized exfoliative salvarsan dermatitis, with heavy secondary infection. These showed a dramatic clinical improvement.

Anæsthesia.—Anæsthesia was best described as of 'continental' quality. Local novocain infiltration was used more freely than in British or American practice, producing a partial analgesia which satisfied at least the surgeon.

Premedication was fortunately efficient, 'S.E.E.' (scopolamine-ephetonin-eukodal) mixture being used for this in ampoules of three standard strengths. It was considerably used as a potent intravenous narcotic for moderately painful procedures such as removal of plasters and difficult dressings, and even for the reduction of dislocations.

Evipan sodium or 'rag and bottle' ether with ethyl chloride, evipan, or open ether induction, were the methods of general anæsthesia. Nitrous oxide was not recognized as an anæsthetic agent, and endotracheal intubation was regarded as a purely theoretical possibility.

ANALYSIS OF DEATHS IN HOSPITAL

Brief summaries of a number of fatal cases during the month were made with the help of our two German doctor interpreters, and the following analysis of these has been made in order to give a broad picture of the main causes of death.

	Mode of Death	*Totals*
Head wounds involving dura:	Primary shock and brain damage	4
	Hæmorrhage	2
	Meningitis	14
		— 20
Penetrating chest wounds:	Empyema	13
	Empyema with secondary hæmorrhage	4
	Empyema with subphrenic abscess	1
	Primary hæmorrhage	3
	Pneumonia with hæmopericardium	1
	Pelvic thrombophlebitis	1
		— 23
Penetrating abdominal wounds:	Peritonitis	11
	Hæmorrhage	1
		— 12
Thoraco-abdominal wounds:	Primary hæmorrhage or shock	2
	Empyema	3
		— 5
Amputations—		
Above elbow:	Anaerobic cellulitis	1
Below elbow:	Septicæmia	1
Above knee:	Septicæmia	3
	Septicæmia and secondary hæmorrhage	1
	Septicæmia and pelvic thrombophlebitis	2
	Septicæmia, pneumonia, and empyema	3
	Septicæmia and fat embolism	3
	Fulminating gas gangrene	1
	Tetanus	1
Below knee:	Septicæmia	4
		— 20
Fractured spine without paraplegia:	Septicæmia	1
		— 1
Fractured spine with paraplegia:	Primary shock	1
	Hypostatic pneumonia	2
	Urinary infection (no suprapubic cystostomy)	3
		— 6
Fractured pelvis without bladder lesion:	Septicæmia	1
		— 1
Fractured pelvis with bladder involved:	Primary shock	1
	Peritonitis	1
	Urinary infection	1
		— 3

	Mode of Death	*Totals*	
Compound fractured femur (without amputation):	Primary shock	1	
	Septicæmia	3	
	Septicæmia with secondary hæmorrhage	1	
	Tetanus	1	
		—	6
Compound fractured tibia and fibula (without amputation):	Septicæmia	1	
	Septicæmia with embolism	2	
		—	3
Compound fractured forearm:	Tetanus	1	
		—	1
Compound fractures involving joints—			
Shoulder:	Septicæmia	1	
Knee:	Septicæmia	4	
	Septicæmia with secondary hæmorrhage	1	
	Septicæmia with pelvic thrombosis	2	
	Septicæmia with lung embolism	1	
		—	9
Burns:	Tetanus	1	
		—	1
Flesh wounds:	Primary shock	1	
	Septicæmia	4	
	Septicæmia with secondary hæmorrhage	1	
	Septicæmia with liver abscess	1	
	Tetanus	5	
	Erysipelas	3	
	Fulminating gas gangrene	1	
		—	16
Wounds of large vessels—			
Carotid artery and vein:	Secondary hæmorrhage, respiratory arrest under evipan	1	
Femoral vein:	Secondary hæmorrhage	1	
		—	2
Appendicitis:	Peritonitis	1	
		—	1
Osteomyelitis of ileum ('primary'):	Septicæmia	1	
		—	1
Hogdkin's disease:	Empyema	1	
		—	1
	Total		132

NOTES ON METHODS IN GERMAN WAR SURGERY*

(*In collaboration with a senior German surgeon*)

The treatment of wounds in the German Army should be carried out as stated in the Army Manual, *Instructions for Treatment of Wounds in the First Medical Units*, published by the German Command.

In this Manual the following suggestions are made as to the treatment of wounds.

The First Medical Aid Post.—

1. Saving of life by treatment of shock and collapse.

2. Transport and operations while in a shocked or collapsed state forbidden, except to save life, i.e., gross hæmorrhage, tracheotomy, and open pneumothorax.

Treatment of Shock.—

1. Warmth—hot-water bottles and hot drinks.

2. Blood transfusion, periston, tutofusin, or serum.

3. Cardiac stimulants, i.e., coramin, cardiazol, camphor, hexeton, strychnine, strophanthin, sympathol, veritol, adrenaline.

Prevention of Asphyxia.—

a. Removal of the cause, i.e., pus and/or other secretions.

b. Fixation of tongue.

c. Removal of damaged tissues.

d. Removal of foreign bodies.

e. Tracheotomy.

f. Suture of pneumothorax.

Treatment of Hæmorrhage.—

a. Pressure.

b. Ligature.

c. In extreme cases tourniquet, which must be released after a maximum period of two hours, and eased every thirty minutes, for a short period. The patient must always be watched for signs of collapse.

*This section is a modified translation from German notes.

First Treatment of Wounds: Antiseptics and Sterile Dressings

First Treatment of Burns.—

1. After washing with antiseptic solutions, dressed with prontosil gauze (sulphonamide vaseline gauze).

2. Burns brushed with 5 per cent tannic acid under anæsthesia. This treatment is continued half-hourly or hourly until a leather skin is formed. Tannic acid treatment is only used for the first 48 hours and when no other treatment has been previously used. Attention is paid to circulation, and blood and serum transfusions are given.

Methods taken to Prevent Infection.—Every wound is treated as if infected. The greatest precautions are taken to prevent secondary infection. Sterile antiseptic dressings; limbs and wound kept quiet.

Prophylactic tetanus: 2500 units.

With large wounds 8 c.c. A.G.G.S. is injected.

Prevention of anaphylactic shock by sensitization test for A.G.G.S. and A.T.S.

Chemical treatment also.

Local and general sulphonamide courses.

General Surgical Treatment.—

1. *Through-and-through small bullet wounds* are treated conservatively. No excision, sterile dressings, and kept quiet. The same treatment is applied where there are fractures and when joints are involved, but only when the wound is the same size as that of a small bullet. This type of wound is only operated on when synovial fluid is being discharged from a joint or when there is an open pneumothorax.

2. *Other types of wounds*: Total excision. Removal of damaged tissues. Total excision must be made within 12 hours of wounding. Primary suture of all war wounds is forbidden. It is possible to suture wounds which are clean, five to eight days old. Primary suture of war wounds is allowed in the following instances: (*a*) Head (involving brain) wounds; (*b*) Open pneumothorax; (*c*) Open wounds of joints.

3. The principal method of treatment of war wounds is by excision. The best results are achieved when the time-lag is less than 12 hours. The method of treatment is determined by the anatomical state of the important structures. Wound excision must be carried out in all large, deep, or lacerated wounds. All debris and devitalized tissue, foreign bodies, and bone fragments being removed.

Tamponade of through-and-through and penetrating wounds is forbidden. Results: retention, secondary infection, phlegmons. Primary suture forbidden. All mine wounds and shrapnel wounds must be surgically treated.

4. *Metallic foreign bodies* may be removed only when they are superficial or when they are found during the operation. It is forbidden to search for metallic foreign bodies in inflamed tissue.

Exceptions:—

a. Metallic foreign bodies near important vital organs (trachea, urethra, blood-vessels, nerves).

b. Penetrating S.W. in brain.

c. Penetrating S.W. of joints (within 48 hours).

5. Local use of M.P. powder. Sulphonamide treatment per os: 2 days 8 g., 2 days 6 g., 4 days, 4 g.

Special Surgical Treatment of Wounds

1. Penetrating S.W. in Brain.—Primary operation as soon as possible. Primary operation with good results as soon as possible until the fourth day.

Exception: Penetrating S.W. with large destruction of the head bones or infection.

Before every head operation a radiograph in two planes must be taken. Treatment of shock, and lumbar puncture.

Reason :—

a. Removal of bone fragments, metallic foreign bodies, and infective material.

b. Ligature of vessels.

c. Prevention of secondary infection.

Surgical method :—

Wound excision. Preparation of the dura in the healthy part 1 cm. around the wound. Aspiration of the destroyed and necrotic brain parts. Removal of bone fragments and metallic foreign bodies. Ligature of blood-vessels, primary suture of dura with a pedicle or free graft from the galea aponeurotica, periosteum, or fascia.

The preparation of the dura depends on the amount of brain destruction and the condition of the dura. Excision and flap closure are then done.

In cases more than 4 days old or large brain wounds with infection, damaged brain tissues aspirated. Bone fragments and metallic foreign bodies removed and open treatment established with rubber sponges or Mikulicz (this is a stout glass tube with closed end and perforated sides. Discharges are mopped up from inside it periodically).

Place for treatment :—

Field hospital, if possible by brain specialists. No transport before 4–6 weeks. Rest after operation is more important than primary operation. Operations are performed with local anæsthesia together with S.E.E. (scopolamine, epketonin, eukodal) or evipan.

2. Wounds of Face and Maxilla.—If possible, primary operation by specialist or dentist.

a. Fractures.—Fractures with little displacement are treated by drilling and wiring of mandible, including as many teeth as possible. Fractures with large bone defects are bridged with wire splint at primary operation. In fractures of mandible with much displacement elastic fixation to the maxilla is done. Fixation is best effected by plaster-of-Paris head cap with loops and rubber bands.

b. Flesh Wounds of Face.—Wound excision. Approximation suture only where there is free drainage. If not, secondary suture after some days or weeks. Operation on the face. Local anæsthesia or S.E.E. Nourishment by stomach tube. Mouthwashes with antiseptic spray.

3. Wounds of the Eyes.—Primary treatment only by specialists within 12 hours. Chemical burns irrigated with water or solution of 5 per cent soda bicarb. (eye vaseline or noviform-vaseline-dressing). Wounds of lid : primary suture. Foreign bodies must be removed. For intra-ocular foreign bodies X-rays in two planes are necessary. For intra-ocular metallic foreign bodies a large magnet and X-ray equipment are essential. Wounds of cornea and sclerotic and prolapsed parts such as the iris are resected and the wound closed with flap of conjunctiva.

Corneal wounds are sewn up with sterile female hair. Sclerotic wounds are sewn up with finest silk. When the eye is destroyed enucleation is performed.

4. Wounds of Ears.—Most of them communicate with head wounds. Primary operation is necessary as soon as possible. Destructive wounds must be examined to see whether middle ear, temporal bone, or mastoid is fractured. Retro-auricular exploratory incision must be made when necessary.

Ear wounds caused by a blunt instrument (perforation of drum, lesion of internal ear) are treated conservatively, irrigations forbidden. Labyrinthine and meningeal irritations must be operated on through a mastoid incision.

5. Neck Wounds.—Small penetrating wounds, afebrile, are treated conservatively.

For wounds of œsophagus, external œsophagotomy is performed. Nourishment is given by means of a stomach tube.

Wounds of larynx and trachea. Tracheotomy is performed. Skin emphysema must be incised.

Wounds of the large neck vessels must be sutured, if possible, when they are damaged. If this is impossible they must be ligatured.

6. Chest and Lung Wounds.—Pneumothorax with high tension : valve drainage. Large hæmothorax must be repeatedly aspirated. After shock treatment every open pneumothorax must be closed as soon as possible.

Lung inflation apparatus during operation is useful. Through-and-through wounds with no large opening of the chest can be treated conservatively.

Wound excision, removal of rib fragments, and metallic foreign bodies. Suture in layers.

Large defects of chest wall can be closed by flaps. Closing of defect by stitching lung into gap has bad results. After operation dressing with elastoplast or jaconet. Dressings are only to be changed in cases of hæmorrhage. Uninfected chest wounds are treated conservatively by aspirations. In cases of infection Bülau drainage must be applied at the lowest point.

7. Abdominal Wounds.—Every abdominal wound must be suspected of perforation of the peritoneum. When the parietal peritoneum is wounded a laparotomy is necessary. Likewise when symptoms of peritonitis are noticed. Liver wounds must be closed by suture or plugged with gauze. Destroyed spleen must be removed (splenectomy). Wounds of stomach and intestines are sutured. When the colon is perforated a colostomy must be done. When the intestines or the colon are wounded the operation depends on the extent of the injury. If possible no resection. After colon operation in every case A.G.G.S. must be injected. Wounds of pancreas must be sutured and a transperitoneal tamponade applied. Wounds of diaphragm are sutured. All operations with ether anæsthesia or local anæsthesia.

All abdominal wounds must be operated on within 12 hours if possible. When there is a hope of good results abdominal wounds must be operated on even after 12 hours. After operation a rest of 3 weeks is necessary.

Localized peritonitis must be treated if possible conservatively. General peritonitis must be operated on.

All abdominal wounds must get antiperitonitis serum (40–80 c.c. intraperitoneal and 20–40 c.c. with infusion of tutofusin intravenously).

Post-operative nursing is important.

8. Wounds of Urogenital Tract.—Hæmorrhage and extravasation of urine must be looked for and dealt with if possible by extraperitoneal operation.

When the bladder is wounded—laparotomy.

Bladder wounds sewn up in two layers. Catheter applied or, better, suprapubic cystostomy. When there is an extravasation of urine, incision and suprapubic cystostomy. Soft rubber catheter applied by urethra or from above through suprapubic cystostomy.

9. Wounds of Limbs.—Flesh wounds are treated according to the general rules of wound treatment. Limb wounds involving bones are always infected compound fractures.

Surgical treatment is necessary to avoid pseudarthrosis. Bone fragments still attached by the periosteum must not be removed. When a fractured femur is infected, the abscess must be incised and drained. Early operation is more important than rest after operation.

Wounds involving Joints.—Treatment depends on extent of the joint wound and destruction of joint.

a. Penetrating G.S.W. and through-and-through G.S.W. are treated conservatively. Sterile dressings, splint and synovial fluid aspirated.

b. When joint is open without fractures : Irrigation only during the first operation is necessary. Capsule sewn up, flesh wound left open, hip spica applied. If possible, no change of dressing. Infected joint wounds must be drained by a long lateral incision. When the joint is still discharging resection of knee-joint must be performed.

Wounds with destruction of joint: Removal of foreign bodies and bone fragments. Joint left open, and hip spica. Resection of the joint or amputation depends on the extent of the destruction. Joints not operated on after 48 hours with signs of infection must be treated with aspiration, irrigation with Klumsky solution (phenol-camphor), arthrotomy or resection. Rest after operation more important than early operation.

Calf Wounds with Fractures.—

Good: Plaster-of-Paris or plaster-of-Paris slab to upper third of thigh. Foot in dorsiflexion. Toes free on the dorsum.

Sufficient: Kramer wire splint to upper third of thigh.

Bad: All dressings not reaching upper third of thigh.

Wounds of Forearm with Fracture.—

Good: Plaster-of-Paris from metacarpo-phalangeal joints to shoulder-joint. Middle position of forearm, light dorsal flexion of the hand, and 90 per cent flexion of elbow-joint.

Sufficient: Kramer wire splint in the same position.

Bad: All dressings below shoulder-joint, or arm, hand, and fingers in other positions.

When the limb is swollen plaster-of-Paris must be opened dorsally.

Amputations.—First point is to save life before saving the function of the limb.

Indications for primary amputation:

a. When the limb is devitalized.

b. When there is no chance of recovery of the function of the limb.

c. In the presence of severe infection to save life.

Indications for secondary amputation:

a. Progressing gas gangrene.

b. Discharging, infected fracture and joint wounds, dangerous to life.

c. Gas gangrene or fracture with damage to the main blood-vessels.

d. Repeated hæmorrhage from main vessels near fractured bones when ligature is not possible.

e. General infection spreading from the limb.

f. Empyema after joint resection, with pyrexia and bad condition for 2–3 weeks.

g. Tetanus, spreading from the distal part of the limb.

Technique of Amputation: Cut in the wound with removal of damaged skin and muscles. Amputation of the bone above fracture. When infection is present amputation above infection.

Secondary Amputation: Amputation with a flap, no primary suture. In clean cases stitches inserted, closed after 5 days. Periosteum and marrow left undisturbed.

10. Wounds of Vessels.—Suture of vessels has no place in Field surgery. It is only possible:—

a. Under the best aseptic conditions.

b. When the wounds are clean.

c. Only large vessels can be sutured.

Contra-indications:—

a. Septic wounds.

b. When the defect is larger than 4 cm.

Operations on aneurysms can be made only in Base hospitals.

11. Wounds of Nerves and Spinal Cord.—In the Field, partially or totally divided nerves must be sutured. Primary complete suture of the nerve must meet easily. The wound must be aseptic. In all other cases secondary suture of nerve.

Treatment of lesion of spinal cord must be performed in Base hospitals.

Surgical treatment is not urgent.

Good nursing is necessary.

Laminectomy is indicated only for penetrating wounds or bone fragments in the spine, when the X-ray shows pressure on the spinal cord.

ORGANIZATION OF THE SURGICAL SERVICE IN THE FIELD

1. First Aid Post in the Line.—

First dressing, tourniquet, Field transport splint. A.T.S. injected.

2. Advanced Dressing Station 1-4 km. behind the Line.—

Revision of dressing (if possible, no change).

Tracheotomy, pneumothorax closed by dressing; making fit for evacuation, by treatment of pain and shock.

Treatment of hæmorrhage, blood transfusion or infusion.

Catheter or puncture of bladder.

3. Main Dressing Station 6-30 km. behind the Line.—

Personnel: 1 C.O.
2 surgeons (1 specialist).
1 medical specialist.
1 dentist.
40 other ranks.
Minimum accommodation: 130.

Tracheotomy, suture of open pneumothorax, primary amputations, ligature of vessels, transfusions, surgical treatment to make fit for evacuation.

4. Field Hospital 30-70 km. behind the Line.—

Personnel: 1 C.O.
1 surgeon.
1 medical specialist.
3 G.D. officers.
88 other ranks.
250 beds, but, as a rule, 500–600 patients.

Surgical treatment, brain surgical treatment, chest wounds, abdominal, joints, fractures, and vessel wounds.

5. Base Hospital.—

Surgical treatment of all wounds with all specialists.

For the treatment of light cases there were established Field dressing stations near the line.

In Italy each army had one Field hospital which had all specialists as at Base hospitals.

DISCUSSION

It is evident that the orthodox German surgical policy was on the whole sound and corresponded in many ways with that of the British Army up to 1942, apart from continental variations.

The Feldlazarett or Field Hospital may be described as the keystone of the German Surgical Service. It can be compared with the C.C.S. of the 1914–18 war, the Mobile C.C.S. of the earlier days of Eighth Army, or the Field Dressing Station, converted into an 'advanced surgical centre' by the addition of surgical and transfusion units, of the later stages of the Italian campaign; in each of these the majority of primary surgical operations being performed. The equipment of the Feldlazarett was good and it was possible with it to maintain a hospital of 200 to 500 beds and provide suitable operating and X-ray facilities. One such hospital during the period October, 1943, to December, 1944, admitted 9486 surgical cases—including 1480 fractures, 1184 joint lesions, 980 brain wounds, and 91 cases of appendicitis, approximately 70 per cent of each group of which required operation.

By comparison, one British Field Surgical Unit might perform between 1500 and 2000 operations in one year, although in one period at a C.C.S. 118 major operations were performed by one surgeon in six days, while an assistant surgeon, working simultaneously, operated upon over 200 minor primary wound cases.

During the different stages of the war it was, of course, necessary for the duties of individual units to alter, depending on whether an advance or retreat was taking place, and on the state of the receiving or evacuating line of communication. The best conditions for treatment, rest, and evacuation on the German side were met with in static warfare and the worst in retreat. Allied air superiority in the latter stages of the campaign caused almost insuperable difficulties in evacuation, resulting in pre-operative delay and post-operative overcrowding at a hospital, such as Abano, which was placed centrally in the evacuation chain. Roads were frequently blocked, necessitating the carrying of wounded around road obstructions; or an ambulance train, unable to reach its destination, might be compelled to return its load. On the British side it can be recorded (Stammers) that "the results of delayed primary suture during the Gothic Line battle were less good than during the Cassino days and this because the lines of evacuation in September and October were very long, and in consequence the optimum time for the delayed suture was missed. As pressure of work eased off we were able to establish delayed suture centres in Army areas and were therefore able to apply delayed suture at the optimum time."

Medical supplies, such as gauze, wool and bandages, were becoming short, and Abano had become filled with patients who were intended for the Base hospitals at Merano and Cortina. Although conditions were not as good as at the Base, these excuses cannot, however, be accepted for the standard of treatment which resulted. The policy as the war progressed had been to send the younger medical orderlies with good experience to the forward units and to replace them by older men; and the former surgical specialists who had been killed or captured had been gradually replaced by recently qualified assistant surgeons or older civilian surgeons without adequate experience of war surgery. It has been suggested that many of these had a false estimate of their own powers and a lack of good judgement —certainly these accusations were fully borne out when some of the surgical work of the hospital group was examined.

Investigation of over 100 death reports, summarized and translated into English, showed that the majority of patients reached the surgeon within one day of wounding. Their operations and subsequent dressings could not possibly have been carried out according to the official instructions and this will be clear after reading the description of the state of both wounds and patients.

Failure in asepsis cannot be excused on the grounds of overwork, bad accommodation, or inexperience. On certain necessary occasions one has maintained a practical standard of asepsis in an underground wine cellar using a simple lamp, a stretcher as operating table, water from a 'jerrycan', and only that amount of theatre equipment which could be carried by some of the C.C.S. staff in the twelve theatre 'landing packs' which were available.

Pressure of admissions has never forced us materially to lower our standards either in forward units or at the Base, and it will be remembered that many of our surgeons also were similarly recently qualified. From personal observation of the cases arriving at a desert hospital during the Battle of Alamein it can confidently be stated that the standard of treatment and surgical handicraft, even before penicillin and delayed suture were adopted, were much higher than those met in Abano some three years later.

Admittedly, a part of the success of British War Surgery can be attributed to the correct use of penicillin, to blood transfusion, to the policy of having facilities for good surgery and post-operative nursing in the forward areas, and to delayed suture; But it is also true that it is only an adaptable surgical service, working with the active assistance of its policy by the administrative commanders, which can enable the necessary research into, and trial and adoption of, these adjuncts to the essential excision operation to be made.

Adaptability has long been the keystone in the training of the British Army, and the conditions at Abano Terme provided us with a valuable lesson in the results of the neglect of this teaching.

"Trotz starker Kreislaufmittel tritt der exitus letalis ein."

SUMMARY

1. The state of the Abano Terme Hospital Centre in May, 1945, and certain aspects of the policy which gave rise to this are described.

2. Notes are given on the orthodox policy in German War Surgery.

3. The differences between the German and British methods are discussed.

We are much indebted to the Specialist Consultants for their advice, and to our colleagues of the British Cadre for their help and co-operation. Our thanks are due to Brigadier W. M. Cameron, O.B.E., D.D.M.S., Eighth Army, and to Brigadier H. C. Edwards, C.B.E., Consulting Surgeon, A.F.H.Q., for permission to publish this article.

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EXPERIMENTAL OBSERVATIONS ON THE USE OF ABSORBABLE AND NON-ABSORBABLE PLASTICS IN BONE SURGERY

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Two main classes of materials have been employed in the course of this experimental investigation: (1) Non-protein plastics of varying origin and composition; (2) Protein plastics.

1. *Non-protein Plastics.*—The chief plastics of this class that have been studied are methyl methacrylate (Perspex), cellulose acetate, Nylon, urea, and phenolics. Experimentally, methyl methacrylate proved to have the most satisfactory characteristics and, in the later work, it alone was studied in detail from the point of view of surgical applicability. The properties and possible uses of methyl methacrylate plastic will be considered later.

2. *Protein Plastics.*—The chief protein plastics studied were made up from casein, fibrin, casein with plasma, red blood-cells, and whole blood. These proteins resemble one another in their physical and physiological properties, differing only in their quantitative characters. The protein plastic chiefly studied was casein plastic.

One fundamental and surgically important difference was established between the non-protein and the protein plastics. The non-protein plastics are not absorbable in animal tissues; the protein plastics on the contrary are absorbable, the rate of absorption depending on various factors. It is proposed to consider first in detail the protein plastics.

PROTEIN PLASTICS

Preparation and Properties of Protein Plastics.—*Table I* shows in outline the method of preparation of casein plastic. The same general procedure with appropriate modifications is employed for the other protein plastics.

Table I.—The Preparation of Casein Plastic

Skimmed milk and rennet
↓
Water and rennet casein
↓
Casein gel
↓ Hot extrusion through Archimedean screw-press
Casein plastic
↓ 4 per cent formalin bath
Fully formalized casein plastic

Skimmed milk is treated with rennet; casein is precipitated. The dry casein powder is treated with water and converted into a gel in a mixing machine, from which it is extruded along a heated Archimedean screw-press under pressure, thus being converted into a plastic. At this stage the material is rubbery in consistency and easily mouldable; if plunged into cold water it becomes rigid and so retains the shape previously imposed upon it. This so-called initial or 'unformalized' plastic is of limited strength, brittle, and subject to putrefactive change. It is, therefore, commercially treated by immersion in a 4 per cent formalin bath. The formalin slowly penetrates the plastic mass from the surface, advancing at the rate of about 1 mm. per 14 days. The formalin unites with the casein to form a condensation product. The formalized plastic is stronger than the unformalized (by up to 30 per cent) and is no longer subject to putrefaction. Material in which the formalin has penetrated the entire mass of the plastic is called fully formalized plastic. In this research, both plastics formalized for periods of 1 to 14 days and fully formalized plastics have been employed. These plastics can be machined to provide screws, plates, blocks (that might be used as grafts), trifin nails, and other objects.

It must be emphasized that the strength of these protein plastics is not in the same class as the metals. Their strength, however, is of the same order as that of bone. Strength, as stated, increases with the degree of formalization; it decreases, however, if the material is stored under unsatisfactory conditions. The best conditions are at comfortable room temperature and at a relative humidity of 75 per cent. In airtight containers, the plastic will remain unaltered indefinitely.

Fate of Protein Plastics in the Animal Body.—As will be explained in detail, the protein plastics are in time completely absorbed in the tissues, giving rise to little if any permanent fibrous tissue reaction. The speed of absorption depends on:—

1. The degree of formalization, fully formalized material being the slowest.
2. The bulk of the implant.
3. The tissue in which it is placed. Thus absorption is (perhaps surprisingly) faster in bone than in skeletal muscle.

When a protein plastic is implanted in a tissue, a series of changes regularly takes place. These changes can be illustrated by experiments in which a casein horseshoe was moulded around two-thirds the circumference of the shaft of the femur in rabbits. The animals were killed at intervals to enable the conditions of the casein plastic to be studied. The sequence of events is as follows: At 2 months the fully formalized protein plastic is hard and rubbery; at this stage it can be cut with a knife with difficulty. It then becomes progressively softer and cuts with increasing ease. At 4–5 months the surface, instead of being homogeneous, is granular and cheesy in appearance. It then becomes quite soft and breaks up into granular particles in a semi-liquid matrix. Finally, the entire plastic becomes mucoidal, then more fluid,

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† Work carried out while member of Staff Research Pool, Directorate of Biological Research, War Office.
‡ Preliminary report, G. Blum, *Proc. R. Soc. Med.*, 1945, 38, 169.

and finally (at about 6 months) it completely disappears as a result of absorption. A capsule of fibrous tissue is formed in the course of absorption and at an intermediate stage may be fairly thick. Usually, however, when the plastic has disappeared the fibrous reaction is found to be greatly diminished.

In a number of experiments some periosteal reaction occurred in the vicinity of the plastic, consisting of the development of slight spurs above and below the plastic. Sometimes after the plastic was fully absorbed, the periosteal changes cleared up completely.

With partially formalized plastic these changes developed more rapidly. Thus, at 2 months such plates might be found to be quite soft, in an advanced stage of disintegration, and lying in a pool of serous fluid containing remnants of softened plastic which had broken away from the main mass. A variable degree of fibrous reaction is present at this stage.

The fate of protein plastics inserted into *bone* was also studied. Rabbits and cats were employed. Screws made of various materials were inserted tightly into drill holes prepared in the shaft of the tibia. In some experiments, screws of protein and non-protein origin were inserted into the same bone for purposes of comparison. The bones were X-rayed at intervals and the animals killed after varying periods to enable detailed studies to be made of the screws and bone. After external inspection, the bones were split longitudinally; photographs and coloured drawings were made and, in some cases, microscopical sections were prepared.

It was found that the protein plastic screws were completely absorbed in 4 to 6 months. It must be emphasized that the screws were of a size suitable for use on the tibia of a cat or rabbit. The very much bulkier screws which would have to be employed in clinical trials might take a longer, or much longer, time to disappear. This, however, might not prove a disadvantage.

The X-ray appearances will first be dealt with. In examining the X-ray plates it is important to remember that all the plastic materials employed are *radiolucent*, though to a varying extent.

Fig. 280 shows the changes observed in the tibia of a cat in which two non-protein and one protein

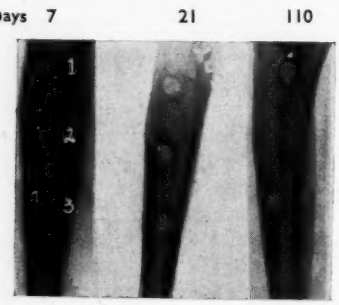

FIG. 280.—Radiographs of tibia of cat. Three drill holes were prepared and into them were screwed: (1) Non-absorbable (cellulose acetate) plastic screw; (2) Fibrin plastic screw; (3) Phenolic plastic screw. Screw (2) had disappeared at 110 days; the others were unaffected.

plastic screws were inserted. No changes were visible at 7 or 21 days. After 110 days, however, the drill hole containing the protein plastic screw was almost completely replaced by bone, the main mass of the screw having been absorbed. There was no sign of the protein plastic screw at 167 days. The animal was then killed and at dissection the hole was found to be substantially filled with hard bone, and there was only a tiny fragment of the plastic visible in the marrow. The non-protein plastic screws had undergone no change.

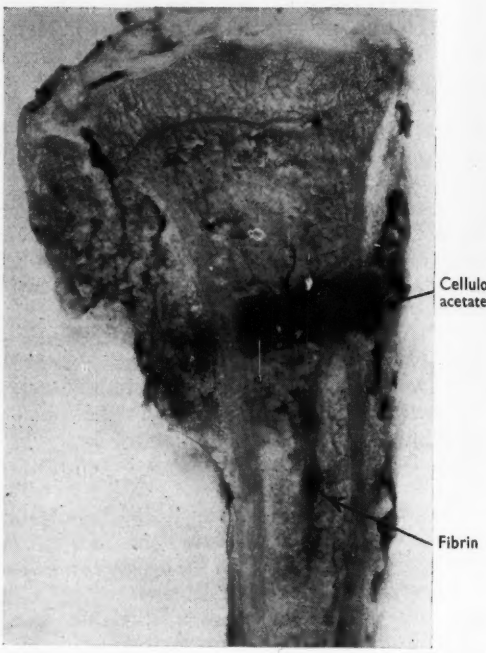

FIG. 281.—Longitudinally split tibia of cat 167 days after operation in which cellulose acetate and fibrin plastic screws were inserted. The cellulose acetate screw is unchanged. The drill-hole originally occupied by the fibrin screw has been filled up by normal *bone*; some remnants are still visible in the marrow cavity.

The appearance at dissection at 167 days of the bone from a similar experiment is shown in a longitudinal section in *Fig.* 281. The upper non-protein plastic screw has undergone no change, though there is some marginal reaction round it. The fibrin plastic screw is represented by small fragments only and its original position has been filled by bony tissue.

Fig. 282 illustrates the appearance found in another animal after 167 days. The casein screw has almost completely vanished except for a small remnant in the marrow, and the drill hole has been completely filled by bone. The methyl methacrylate and urea formaldehyde screws are quite unaltered, the former especially showing its thread perfectly. There is no obvious reaction around these screws.

At dissection the changes undergone by fully formalized casein screws in bone are found to be as follows: At 1 month the screw is still fairly hard, but is becoming more elastic and rubbery; it is firmly held in the bone. At 2 months the screw is still firmly lodged, but is more easily bent. There is no bony encroachment. At 4 months the screw is still homogeneous and intact, but is very malleable. There is still little bony encroachment. At 6 months traces of disintegrating plastic are still visible, but in the main the original drill hole is filled up with

new bone. No rarefaction takes place in the bone around the screw. The replacement of the screw by fresh bone follows closely on the progressive dissolution and disappearance of the screw.

In the case of partially formalized screws, the changes are similar in character, but occur considerably more rapidly. Thus at 2 months the screw

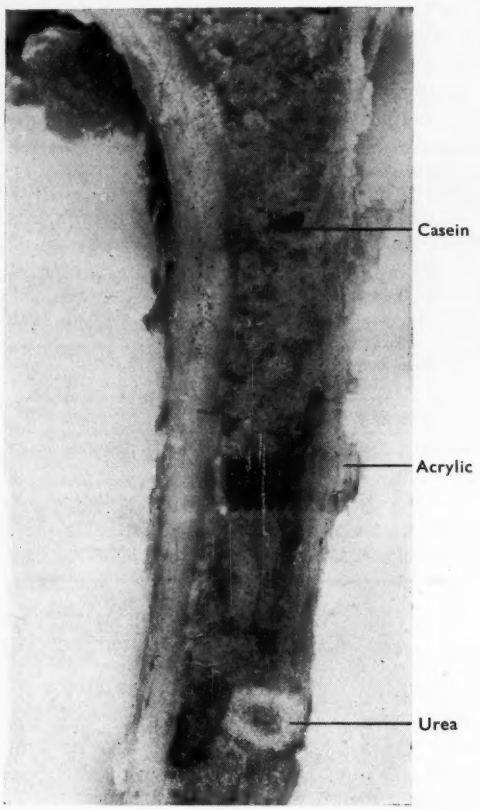

FIG. 282.—Longitudinal section of tibia of cat 167 days after insertion into drill holes of the following plastic screws from above downwards: (1) Casein; (2) Methyl methacrylate; (3) Urea formaldehyde.

may be quite soft and bony encroachment has already occurred. At 3 months the screw is disintegrated and the remnants are very soft; bone proliferation is proceeding actively. The speed of absorption of the protein plastics in bone is in inverse ratio to the degree of formalization.

In another experiment a study was made of the fate of three casein screws, one formalized for 24 hours, one for 7 days, and one fully formalized. After 3 months the 24-hours formalized screw had almost completely disappeared. The fully formalized screw was rubbery in consistency, but almost intact; the 7-days formalized screw was softer and already somewhat encroached upon. Similar differences can be seen in the specimen from a tibia after 2 months (*Fig.* 283). The thread on the surface of the fully formalized screw can be readily made out; in the 7-days formalized screw the thread is no longer visible and the margins of the screw are undergoing erosion.

The initial changes in consistency and tensile strength of the protein plastic may be due largely, if not wholly, to physical factors. If casein or other protein plastics are kept immersed in saline at 37° C. or suspended in sealed test-tubes above water in an atmosphere saturated with water vapour at 37° C. they become malleable and easily breakable after a period of one to several weeks. It is likely that the further softening and ultimate disintegration and liquefaction that occurs in the body is due to the action of proteolytic enzymes which break down the casein or fibrin of the plastic into the usual soluble simpler derivatives such as peptones, polypeptides, or amino-acids. These products may be responsible for the heavy cellular infiltration commonly noted at an intermediate stage at the margins

Fig. 283.—Longitudinal section of tibia of cat 2 months after inserting formalized casein plastic screws into drill hole. The screws are split in their long axis. 1, Fully formalized; 2, 7 days formalized.

of the softened plastic; ultimately, however, the plastic does completely disappear and in bone the plastic is replaced by bony tissue.

Non-toxicity of Protein Plastics.—The most sensitive index of tissue response to foreign bodies is the effect produced by the substance on explants of embryonic tissues. Miss Honor Fell (of the Strangeways Laboratory) kindly carried out such tests, the results of which are seen in *Table II.*

Table II.—EFFECT OF ABSORBABLE PLASTICS ON EMBRYONIC EXPLANTS OF TISSUE

SUBSTANCE: (3 PLATES OF EACH)	24-HOUR RESULT	48-HOUR RESULT
1. Fibrin plastic	Good growth	Growing well: bits of plastic incorporated in tissue
2. Casein plastic	Fair growth	Same as in 1
3. Fibrinogen plastic	Fair growth	Same as in 1 and 2

The tests were carried out with the plastics in granular form; the casein plastic examined was fully formalized. It is clear that none of these protein plastics has any harmful effect on these highly delicate proliferating embryonic explants.

The protein plastics employed can be satisfactorily sterilized by autoclaving for 20 minutes at 15 lb. pressure at 120° C. They must, however, be dried and cooled to maintain their tensile strength.

The results so far recorded can be summarized thus:—

1. The protein plastics employed are not harmful to tissues.

2. The protein plastics are completely absorbed in soft tissues and in bone.

3. The protein plastics inserted in bone are completely replaced by new bone.

As these are protein plastics, one has to bear in mind the possibility of sensitization developing. No evidence of allergy has been obtained in animal experiments. In some animals protein plastics have been inserted on several occasions in the same animal without harm.

The question arises whether these absorbable plastics have any field of usefulness clinically. The observations in experimental animals suggest that no great risks would be involved in carrying out clinical trials by using 'hard' protein plastics in bone surgery. The protein plastics suffer, however, from one serious disadvantage which will have to be overcome before they can be employed in any position where they are subjected to significant strain; this disability is the rapidity with which they undergo softening and loss of tensile strength when exposed to moisture at a temperature of 37° C. As already mentioned, specimens immersed in saline at 37° C. or suspended over water at the same temperature, in sealed tubes generally began to soften in 10–14 days. There was a good deal of variability in the changes shown by different batches of the plastic, but even the most resistant began to soften in about 4 weeks. Resistance to moisture and to other destructive agents, however, has been shown to be enhanced by increased formalization. It may be possible in the near future to subject screws or plates to a process of case hardening or other form of treatment which may enable them to retain their original physical properties for longer periods. If the protein plastics could be treated so as to remain substantially unaltered in physical properties in the body for about 3 months before they undergo the disintegrative changes already described, their field of clinical usefulness might be extensive.

NON-PROTEIN PLASTICS

As already mentioned, prolonged experiments up to periods of 9 months showed that plastics derived from non-protein sources are not changed and, therefore, are not absorbed in the soft tissues or in bone. Individual compounds vary in the degree of tissue response which they produce. Experiments by Miss Fell (*Table III*) on embryonic explants show that some of them kill this delicate tissue: methyl methacrylate tested in this way produced no deleterious effects.

In a general way, the gross responses of animal tissues to the presence of these plastics agree with the findings of Miss Fell. Methyl methacrylate plastic is well tolerated by the tissues and often produces little or no fibrous reaction. Frequently even the plastics which are most lethal to tissue cultures produce little gross tissue reaction. Thus, for instance, urea plastics were well tolerated in tissues and also showed a bacteriostatic effect *in vitro*. The tissue response found to the plastics investigated has been recently confirmed by Bailey, Hawn, and Ford (1943), and Ferry and Morrison (1944); both teams of workers investigated plastics, especially protein plastics, for their possible use in other fields of surgery (e.g., brain surgery). They also found protein that plastics were absorbable. Bailey, Hawn, and Ford recorded tissue reaction in the presence of methyl methacrylate, Nylon, and vinyls.

Methyl Methacrylate.—In view of Miss Fell's findings, and also for certain physical reasons, methyl methacrylate was selected for more prolonged and detailed experimental study. This plastic is derived from acetone-cyanhydrine by a complex series of reactions. Pressure-polymerized methyl methacrylate (Perspex) is perhaps stronger than protein plastics, but is not comparable in strength with steel. A long series of experiments was carried out using methyl methacrylate plates, tubes, and screws in the treatment of fractures in experimental animals. On the whole, the results suggest that this (or any other non-absorbable) plastic used in this manner has no outstanding advantages over the metals and has the disadvantage of being a much weaker material.

Table III.—Effect of Non-absorbable Plastics on Embryonic Explants of Tissue

Substance (3 Plates of Each)	24-hour Result	48-hour Result
1. Urea (and formaldehyde)	No growth	Dead
2. Phenol (and formaldehyde)	Fair growth	Growing well. Bits of plastic incorporated in tissue
3. Cellulose acetate	2 no growth 1 fair growth	2 dead; 1 poor, sick, outgrowth
4. Methyl methacrylate	Fair growth	Growing well
5. Nylon	Fair growth	Growing well
6. Steel	Fair growth	Not very good; 2 have (?) cellulose acetate fragments incorporated.
7. Control	Fair growth	Normal

Methyl methacrylate is characterized by the variety of ways in which polymerization can be attained. By the use of plasticizers, its physical properties can be changed and thus, for instance, 'inhibited' methyl methacrylate will polymerize into a flexible sheet instead of into a hard sheet. Polymerization to produce a hard plastic can be carried out with either of the following techniques:—

1. Pressure and heat polymerization by 'injection moulding'. This is the process leading to the formation of 'Perspex' sheets commonly used in aircraft construction.

2. Mixing the monomer and polymer in correct proportions to form a dough: (*a*) With pressure and heat a similar product to that in (1) is obtained; (*b*) Without pressure and heat, a plastic of granular appearance is obtained which is much weaker than the pressure-heat product.

3. Addition of a catalyst (benzoyl peroxide, benzoin) to the monomer turns the liquid monomer into a final product akin to the one described in (1). When heated on a waterbath at 50° C., this result can be attained in 2–4 hours. If the monomer is allowed to stand at room temperature, the process may take up to 1–2 weeks. The concentration of the catalyst determines the speed of the polymerization.

Methyl methacrylate is being widely used clinically at present for different purposes. Thus it is being employed in the manufacture of dental baseplates, artificial teeth, and dental fillings; for Gunning splints used in the treatment of fractures of the mandible in edentulous patients and for the filling of gaps in the cranium and in facial bones. The technique at present employed for all these purposes is a lengthy one. For example: in preparing an obturator cap for a skull defect the following steps are necessary: an impression is taken of the defect; the impression is then cast; a wax replica is prepared which is transferred to a dental flask where the wax is replaced by methyl methacrylate dough and polymerized under heat and pressure. These steps take 2–2½ hours in the hands of an experienced dental technician. The cap has to pass through a final finishing process before it is ready for use. Its insertion into the gap therefore involves a second operation. This, incidentally, is also the case with tantalum, a new alloy now widely used in brain surgery for the filling of bony gaps (the high cost of tantalum is another factor to take into consideration).

Methods have, therefore, been adopted which enable methyl methacrylate to be used for these and other purposes in a much shorter time, of the order of 15–20 minutes. If such procedures were employed, for example, in the filling of bony gaps they would enable the operative treatment to be completed in one sitting. The methods recommended will now be described.

1. *Moulding of Sheet Material.*—Fully polymerized methyl methacrylate sheet, when heated to 130° C., becomes readily mouldable and soft to handle. Pressed to a model it takes the exact shape of the 'master' and retains this acquired shape if rapidly cooled. The details of this method are as follows:—

a. An impression is taken of the bony defect with a sterile impression material, such as Zelex. The impression material, carried in a tray, is in the form of a thick paste when pressed into the gap; after 2–3 minutes contact, it becomes hard and shows the exact "negative" of the contour.

b. Sterile plaster-of-Paris (which has been worked into a paste) is now poured into this negative mould. This sets in about 5 min. and thus provides a "positive" model of the gap.

c. This model is now transferred to a hand-press. The tray carrying it fits into the base of the press, into the upper moving platform of which is inserted a cylinder filled with sorbo rubber.

d. A sheet of plastic of the required size is meanwhile heated on a heating plate. Exposure to 130° C. for 1–2 minutes is sufficient to make it soft and rubbery.

e. The plastic is now transferred to cover the model and the cylinder filled with sorbo rubber is quickly pressed home. Pressure is kept up for about 2–3 minutes, which is sufficient to allow the plastic to cool and retain its acquired shape.

If the above procedure is carried out under aseptic conditions it is unnecessary to sterilize the prosthesis further. If heat sterilization, however, is decided on, it is important to remember that only unplasticized, pure methyl methacrylate sheet will withstand sterilization by boiling or autoclaving. Plasticized sheet undergoes deformation at about 80° C. and thus loses its acquired shape. Therefore, unplasticized sheet must be employed if heat sterilization of the final product is to be carried out.

The advantages of this method are clear. It allows fitting of a good prosthetic plate in a reasonable time, making a second operation unnecessary, and thus also reducing the period of hospitalization.

2. *Use of a 'Light Accelerated' Monomer.*—As previously mentioned, one of the techniques of the polymerization of this plastic depends on the conversion of the monomer (with catalyst) into a polymerization product. Another technique described was the mixture of monomer and polymer into a dough. With either of these two methods the speed of final hardening depends on heat, pressure, and the proportion of ingredients. Thus, for instance, a 1 : 4 monomer and polymer dough, inserted into animal tissue as a paste, will harden up completely in 24 hours.

Light of 3250 Angström units (ultra-violet light) acts on a dough of monomer (containing 2 per cent beonzoin) and very finely ground polymer in the proportion of 1 : 4 as a very potent accelerator of the reaction. Polymerization is attained in about 15 minutes. The temperature at which this polymerization takes place is under body temperature; its optimum is about 85° F. at a focus of about 4–5 in. Slight variations in time of polymerization must be allowed for, depending on the size and thickness of the area to be hardened.

A series of experiments on cats and rabbits was undertaken to test the tissue reaction to this procedure. The dough was inserted into skull gaps and also around the exposed and roughened laminæ and spinous processes of the dorsal spine. No unfavourable tissue reaction occurred. In the skull-gap experiment there was no dural reaction; the underlying brain was normal; some ossification took place across the floor of the gap between the plastic and the dura. In spinal fixation the bony and soft tissues looked perfectly normal after 3 months.

This method might be of particular interest to the plastic surgeon. The filling of bony gaps and defects in the face, especially when the gap is not a whole-depth gap might be worth considering. The use of methyl methacrylate dough in arthrodesis (either by the accelerated or delayed method) may also be worth a trial.

SUMMARY

1. The behaviour of non-absorbable (non-protein) and absorbable (protein) plastics in animal tissues has been studied.

2. Protein plastics are fully absorbable in tissues without causing unsatisfactory tissue reactions. In bone the protein plastics are replaced by bone.

3. The possible clinical uses of protein plastics in bone surgery are considered.

4. Out of a number of non-absorbable (non-protein) plastics tested methyl methacrylate was found to be most satisfactory from the point of view of possible clinical use in bone surgery.

5. Two methods of using this plastic are described: (*a*) A rapid moulding technique of acrylic sheet; and (*b*) Rapid polymerization by

ultra-violet-ray acceleration. Their usefulness in bone surgery is outlined. Both methods allow the plastic to be used at the time of the first operation, making a second operation for their insertion superfluous.

My thanks are due to Professor Samson Wright, in whose department and under whose supervision this work was carried out; to Major-General D. C. Munro, Consulting Surgeon to the Army, Brigadier W. Rowley Bristow, Consulting Orthopædic Surgeon to the Army, and Brigadier F. A. E. Crew, Director of Biological Research, War Office, for permission to carry out the work; to Erinoid Ltd., and the Medical Supply Association for a grant to cover technical expenditure (as authorized by the M.R.C. and the War Office), and much valuable assistance in the provision of protein plastics and accessories; to Imperial Chemical Industries, Plastics Division, for advice and supply of acrylics; to Dr. C. A. Redfarn, Consultant in Plastics Chemistry, for much information about plastics; and to my staff, L/Cpls. P. Hodgkins and F. Lawton, and V.A.D. Cpl. M. M. E. East, for technical assistance.

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INTERESTING CERVICAL TUMOURS*

A REPORT OF THREE CASES

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THE following cases of cervical tumour are, I believe, of sufficient interest to warrant their recording. They each present features which are somewhat uncommon.

CASE REPORTS

Case 1.—John McR., aged 55 years, was admitted to the Royal Infirmary, Edinburgh, on March 22, 1944, complaining of a swelling on the left side of his neck.

HISTORY.—During the summer of last year, towards the latter half of July, he found that his collars were becoming too tight and he noticed that a swelling had developed on the left side of his neck. It was quite painless. He had no other symptoms.

On reporting to his doctor, he was referred to the hospital in his home town, where a biopsy was performed. He was subsequently treated with X rays, and the swelling disappeared. Towards the end of February, 1944, he again noticed a swelling in the neck, at the original site, which seemed to him to be bigger than previously, and on this occasion his doctor referred him to the Royal Infirmary, Edinburgh.

ON EXAMINATION.—There was a large, firm, solid swelling on the left side of the neck in the anterior triangle, lifting up the sternomastoid muscle and displacing it backwards. It was fairly smooth to feel, appeared to extend deeply, and to be relatively fixed. Its outline could not be defined. The skin over the swelling was slightly reddened and seemed to be fixed to the tumour. There were no other features; no change in voice, no dysphagia, no dyspnœa, no irritation of the throat. Cardiovascular and respiratory systems were normal.

At this time we had no report of the result of the biopsy done previously, and in view of the fact that he had also had X-ray therapy, it was decided to do a second biopsy in order to determine the nature of the swelling. This was done soon after admission, three or four small pieces of tumour tissue being snipped off through an inch-long incision. The pathologist in the Department of Clinical Surgery reported as follows:—

Microscopical Sections: "The sections show the tumour to be composed of groups of cells, somewhat epithelioid in appearance. The most striking feature is the sinusoidal arrangement of the blood-vessels and the fact that the sinus cells are separated from the blood by the endothelium of the sinuses only, without the intervention of adventitious tissue. The appearances are suggestive of a carotid body tumour".

Two or three days later we received information from the hospital where he had first been treated by biopsy and deep X-ray therapy. They informed us that at the original operation, although the tumour was not fixed to the skin or underlying tissues, it was found to encircle closely the carotid vessels, and total removal was not possible; a part, therefore, was removed for examination.

Pathological examination showed what seemed to be a secondary carcinoma invading the tissues, the cells being cubical and columnar, suggesting origin in a mucous surface.

An examination of the larynx and pharynx was done, and there was seen to be a thickening in the region of the left arytenoid, with œdema and an appearance suggestive of new growth in the lateral wall of the pharynx immediately above this. Under direct laryngoscopy a biopsy was performed, the sections of which were reported as being 'anaplastic squamous epithelioma'.

He was treated by deep X-ray therapy, being given maximum dosage, and suffered a fairly severe reaction. The swelling on the left side of the neck disappeared, and in January, 1944, he seemed quite fit.

After receiving this information we had him examined in the Ear, Nose, and Throat Department. The report was as follows: "On examination there is a want of movement of the left arytenoid, with a large polypoidal mass overhanging the arytenoid. Whether this is coming from the arytenoid itself, or from the lateral wall of the pharynx, is difficult to say. We are arranging to examine him with a laryngoscope".

The photographs reproduced here (*Fig.* 284, A, B) were taken on April 14. The tumour has fungated through the biopsy scar.

Something had to be done for the patient, and operative removal being out of the question, and also further

* From the Department of Clinical Surgery, University of Edinburgh.

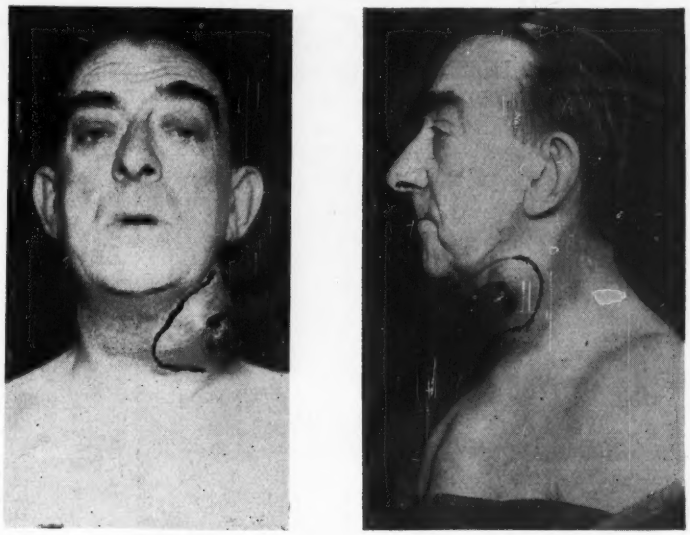
deep X-ray therapy being thought inadvisable on account of the dosage previously employed, it was decided, in consultation with the radiologist, to implant radium needles.

Shortly afterwards laryngoscopic examination was carried out, and on this occasion the finding was as follows: "On examination there is a curious œdema of the posterior pharyngeal wall, limited to the left side. This goes right down the left lateral pharynx, and the left pyriform sinus is œdematous. There is a marked œdema of the posterior wall at the level of the tip of the left arytenoid which obliterates the view of the larynx, but on pushing this aside it is noted that the œdema extends along the left false cord. The left arytenoid is moving, though not so well as the right. The cords are almost normal and the trachea is normal with normal tracheal rings. There is no suggestion of any ulceration in the naso-pharynx or hypopharynx".

In a personal communication the ear, nose, and throat surgeon stated that in his opinion the œdema was entirely due to lymphatic blockage.

On June 13 the patient was discharged to the convalescent home. The tumour mass seen in *Fig.* 284, A, B had entirely disappeared, leaving a round hole about the size of a sixpence, with a sloughing base.

He remained quite well for about three weeks, when he was readmitted following a severe hæmorrhage from the wound. This ceased, but his general condition rapidly deteriorated, and he finally died on July 29, almost exactly four months after admission. Autopsy was refused.



A B

FIG. 284.—A, The growth is outlined, showing the extension anteriorly. It has fungated through the biopsy scar. B, Shows the extent posteriorly (outlined).

Discussion.—Microscopical examination of the tissue removed by us indicated that this was a carotid-body tumour. *Figs.* 285, 286 show the appearance.

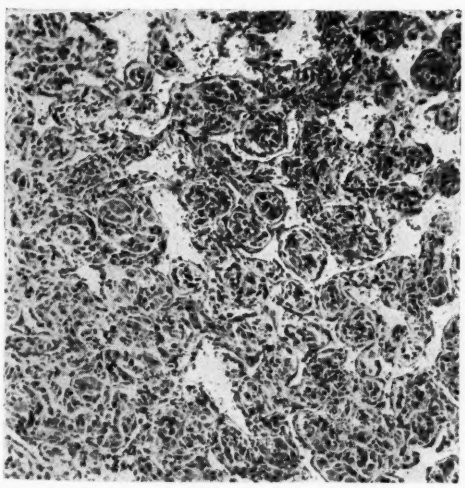


FIG. 285.—*Case* 1. Note the groups of epithelioid-like cells, separated by wide blood-sinusoids. (× 100.)

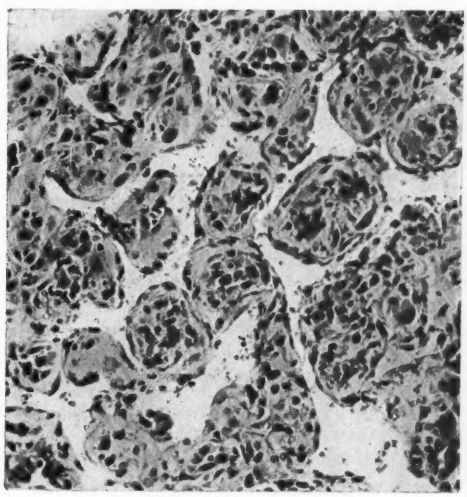


FIG. 286.—Same case. High-power view, showing the endothelial lining of the sinuses only between the cells and the blood-spaces. The cells are polyhedral with granular cytoplasm. (× 400.)

It is that which is typically described as being the picture of carotid-body tumour—"The common appearance is that of masses of polyhedral granular cells . . . The blood-vessels, in the form of sinusoids, may be very numerous, and give the tumour a hæmangiomatous appearance" (Illingworth and Dick, 1938).

According to Hertzler (1937): "The gland is made up of polyhedral cells lying in juxtaposition and forming alveolar-like groups without intervening connective tissue. The cells lie in contact with blood-vessels or blood-sinuses".

The photomicrographs reproduced show these features. The appearance is very like carotid-body tumour. To quote Hertzler again: "A photomicrograph should be published for the benefit of sceptics if the tumour is reported in the literature as a carotid-body tumour".

Compare *Fig.* 255 with the photomicrograph on p. 98 of Hertzler's monograph. The similarity is exceedingly striking.

When, a few days later, the patient was again examined in the E.N.T. Department, and it was

found that the swelling, previously reported as a polypoid mass, and thought to be a primary pharyngeal tumour, was the swelling of œdema, and the arytenoid, pharyngeal wall, etc., showed no evidence of true tumour, we felt more certain of our diagnosis. The laryngologist stated that he considered the œdema to be due to lymphatic blockage, and in view of the extensive infiltration of the tumour this seemed a reasonable explanation.

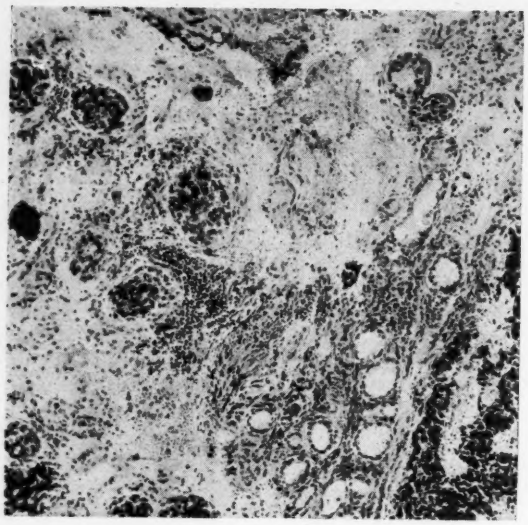


FIG. 287.—Same case. In the lower half of the photomicrograph can be seen normal racemose glands. Above and to the right is seen hyperplasia of the lining epithelium, with cells erupting through the basement membrane. Above and to the left are groups of frankly malignant cells lying free in the stroma. (× 70.)

A second pathological opinion was sought, and the slide was reported as being 'suggestive' of carotid-body tumour, but attention was drawn to the large number of mitotic figures present, an unusual feature of this type of neoplasm, which, of course, is relatively benign, although occasionally marked evidence of malignancy is seen, as described by H. H. Stewart (1931).

On receiving information from the patient's own hospital that a biopsy done previously had shown a picture suggestive of a secondary invasive carcinoma, the cells being cuboidal and columnar in type, and also that a biopsy from the pharynx revealed a picture resembling anaplastic squamous epithelioma, we had to review our diagnosis and re-study our sections with great care, especially as the previous report was made by a pathologist whose opinion carries a great deal of weight. He very kindly cut further sections from his blocks, the slides of which are reproduced here—*Fig.* 287 showing the tissue removed from the pharynx, and *Fig.* 288 that removed from the neck.

Examination of these further sections enabled us to trace the origin of the tumour to the mucous glands in the wall of the pharynx, and *Fig.* 287 shows transition from normal racemose glands to frank malignancy.

The difference between *Figs.* 285 and 286 and 287 are quite marked. Where, then, does the explanation lie? We have two pathological reports, quite different, made on the same tumour, and two microscopical slides showing marked differences. (I would like to state here that there is no question of the slides having become mixed, and being from two different individuals.)

Had we not received information from the hospital in which the patient was treated previously, we would have felt quite confident of our diagnosis of carotid-body tumour (*see Figs.* 285, 286) and perhaps

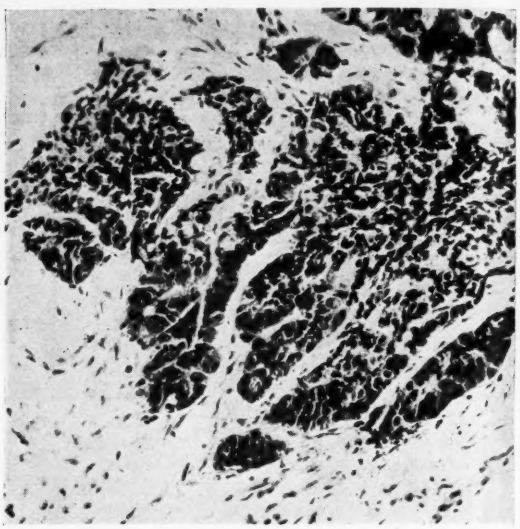


FIG. 288.—Same case. Tissue originally removed from neck, showing glandular carcinoma with some attempt at acinar formation.

have published the case, in all good faith, as an example of that tumour.

The explanation lies, I feel, in the changes which must have occurred between cessation of treatment in the summer of 1943, coincident with the disappearance of the swelling, and the reappearance of the tumour in February of the next year. During the further growth of the tumour mass in the neck, after the effects of deep X-ray therapy had worn off, a tremendous increase in vascularity occurred, and many thin-walled blood-vessels and blood-sinuses were formed, which surrounded and separated groups of cells into spherical clusters, to produce with extraordinary exactitude the deceitful picture (*Fig.* 285) of carotid-body tumour.

This case makes one reflect back and wonder if any case, previously thought to be a carotid-body tumour, could possibly have had some hidden origin, and a similar explanation.

Case 2.—George P., aged 42 years, a farmer. This patient was admitted on March 29, 1944, complaining of "swelling in the right side of the neck, of five weeks' duration".

HISTORY.—In January, 1944, the patient had severe neuritis of the right arm, worse on the dorsal aspect of the arm, and felt especially badly over the scapular region. He retired to bed and has been in bed since then. The pain was very severe, every movement being excruciating. After three weeks of this, he visited his doctor, who gave him injections of vitamin B—twelve in all. These injections did cause most of the pain to vanish. About five weeks before admission (i.e., seven weeks after onset of symptoms) he began to lose his

voice, and he was troubled with cough and a clear watery expectoration. About the same time as he began to lose his voice, he noticed a small lump on the right side of the neck, in the supraclavicular region. During the last two weeks he has had some difficulty in swallowing.

Previous History: Nil.

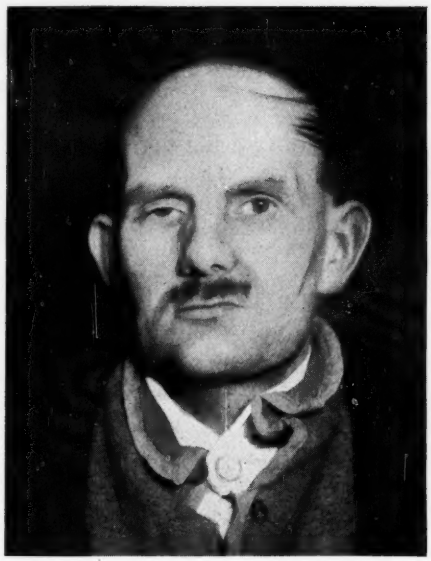


FIG. 289.—*Case* 2. Showing typical Horner's syndrome.

ON EXAMINATION.—Pulse 94. Blood-pressure 160/82. A thin, though not emaciated, man. Good colour. Healthy looking. On the right side is a typical Horner's syndrome (*Fig.* 289). Voice is a slight whisper. In the right supraclavicular region is a firm, fixed swelling, about 1½ in. in diameter. There is wasting of the muscles of the thenar eminence of the right hand and less marked wasting of other hand muscles.

X-ray Examination (Feb. 23).—"Trachea shows slight displacement to the left in the root of the neck. There is some increased soft tissue shadow to the right of the midline".

Biopsy (March 30).—On exposing the swelling in the root of the neck, it was seen to be cystic and bluish in colour, and on incision a quantity of clear, yellowish fluid escaped. The tumour proved irremovable. A piece of the wall was removed.

Severe hæmorrhage developed, and it was found that the tumour had invaded the vertebral artery. The friable vessel wall tore with artery forceps, and a tight pack was inserted and the wound closed around.

April 7: Wound partially reopened and pack very slowly removed. No further hæmorrhage occurred.

PATHOLOGICAL REPORT.—

1. Fluid from cyst: There are a small number of mononuclear cells present. No organisms. Cultures sterile.

2. Biopsy tissue: The tissue is heavily infiltrated with squamous epitheliomatous tumour growth. In places there are many well-formed cell-nests; elsewhere the tumour cells are undifferentiated. There is a well-marked fibroblastic reaction. (*Figs.* 290, 291.)

Discussion.—This case, with one exception, has a clinical picture which fits in very well with the description of a tumour occurring at the thoracic inlet known as the 'superior pulmonary sulcus tumour', or Pancoast's tumour. Pancoast (1932) described these tumours as occurring at the thoracic inlet, characterized by pain around the shoulder and down the arm, Horner's syndrome, atrophy of the muscles of the hand, and X-ray evidence of a small homogeneous shadow at the right apex, plus "always more or less local rib destruction and often vertebral infiltration".

This patient presented all these features, except the bony destruction, but this may occur late, and at present the tumour (or rather the symptoms) date only from January, 1944, a matter of four months. In Pancoast's account of his cases, I note that the rib involvement began anything from three to nine months after the onset of symptoms, so the absence of involvement of bone I do not think weighs heavily against the suggested diagnosis of superior pulmonary sulcus tumour.

Histologically, the tumour is a squamous-cell epithelioma, showing typical cell-nests, a fairly dense fibrous stoma, and areas of undifferentiated cells. Pancoast suggested that these tumours might have their origin in branchial rests, similar to branchiogenic carcinoma.

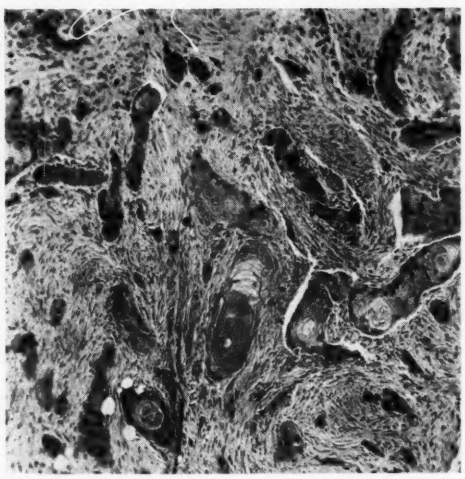


FIG. 290.—Same case. Showing groups of epithelial cells with a well-marked fibroblastic reaction. Cell-nests are well seen. (× 100.)

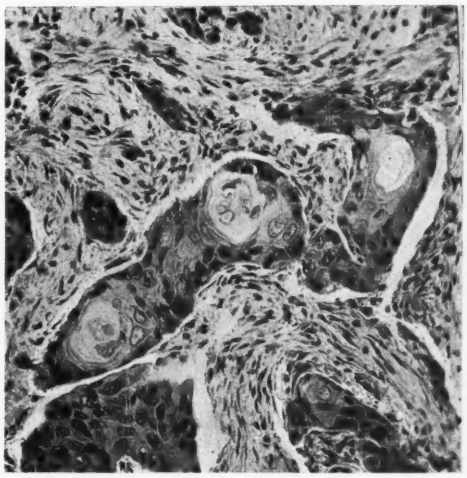


FIG. 291.—Same case. Squamous epithelioma, showing characteristic epithelial pearls. (× 400.)

Morris and Harken (1940) point out that the symptomatology associated with the superior pulmonary sulcus tumour is by no means pathognomonic, but can occur from many conditions causing lesions in the pulmonary apex, and they cite various authors, showing that the syndrome can be caused by such conditions as carcinoma of the lung, metastases from carcinoma of the stomach, from hypernephroma, tumour of the thymus, various types of apical tumour, tumours of the sympathetic cord, and advanced apical tuberculosis, among other conditions.

These two authors do maintain, however, that the superior pulmonary sulcus tumour does occur as a separate and definite clinical entity, and they support Pancoast's hypothesis that it arises from branchial rests. " In the main, the assumption of a branchial origin for the ' superior pulmonary sulcus tumour ' must necessarily be founded upon evidence which, although of an indirect type, is nevertheless impressive. Given a malignant epithelial tumour, primarily in the apical region where no epithelial tissue is found normally, and granted the opportunity to exclude lung, pleura, and other local structures as a source, this assumption is not unwarranted."

In *Case* 2, with a microscopical picture of epithelioma, and a fairly extensive tumour mass eroding the vertebral artery, and yet with apparently no involvement of lung, one could agree with Pancoast that it is unlikely to be due to primary lung carcinoma, as Horner's syndrome is produced so early, and the type of cell is not so likely to be found in an apical lung lesion so far away from the larger bronchi.

Morris and Harken give the following criteria for the diagnosis of a true superior sulcus tumour :—

" 1. Clinical evidence of an apical tumour expressed in terms of pressure destruction effects upon adjacent nerve and osseous tissues." This effect they term Hare's syndrome, pointing out that Hare described this syndrome thirty-one years before Horner.

" 2. Histological evidence of epithelioma."

" 3. Pathologic evidence, based upon biopsy, operative, and post-mortem studies, which are competent to prove (*a*) the extrapulmonary character of the tumour ; (*b*) its ' lack of origin from lung, pleura, ribs, or mediastinum ' ; and (*c*) its primary nature as determined by especially planned methods designed to exclude all possible sources of metastatic origin."

In this case there has been no post-mortem examination, so that final and conclusive evidence is not available. Clinically, however, there is no other source. The microscopical picture fits. At operation the tumour was cystic. Pancoast suggested that these tumours might arise in branchial rests. Tumours of branchial rests are of several types. Oliver (1935) gives a very full account of branchiogenic carcinoma, and shows that few occur low in the neck, but they do occur there.

There are two predominant types—cystic and solid. *Case* 2 is cystic. In Oliver's series, solid were predominant, although Ewing (1940) states that the cystic type are most common.

Crile and Kearns (1935), discussing branchiogenic carcinoma, record one case occurring near the clavicle, and also record Horner's syndrome and pain down the arm in the symptomatology. Squamous-cell carcinoma is the characteristic pathological picture. Grossly, if the origin of the tumour is a cyst, some evidence of cyst wall is found, and often yellowish, semi-solid content. In this case there was definite cyst formation, and a clear yellowish fluid content was found. Pathologically the tumour could be described as a cystic type of branchiogenic carcinoma, and one would put this down as the diagnosis, were it not for the position in the thoracic inlet.

The term " superior pulmonary sulcus tumour," referring to a definite growth, of squamous epitheliomatous type, occurring in the thoracic inlet, and furthermore which is assumed to have a branchial origin, seems to me to be unnecessarily long and confusing. Until further knowledge comes to light regarding the origin of these tumours, it would seem reasonable to regard them only as branchiogenic carcinoma, and for purposes of simplification the term ' low branchiogenic ' is suggested. The addition of the simple adjective as a qualification to ' branchiogenic ' gives at least an indication of position, pathology, and possible origin. The long term indicates only position.

Case 3.—Miss W., aged 73 years, complained of swelling in the left supraclavicular region of a few months' duration.

HISTORY.—For the last few years the patient has had pain in the left shoulder, radiating down the arm to the wrist and up to the neck. During the last few months she has noticed a swelling in the supraclavicular region on the left side, and for the last few weeks she has had the impression that the swelling was increasing in size and becoming harder.

She has no other symptoms. She eats a full diet and enjoys her food ; her bowels are regular ; she has no urinary symptoms.

ON EXAMINATION.—There is a moderately hard swelling in the left supraclavicular region, measuring 2–2½ in. across. It is quite painless to touch, fixed, and appears to extend far medially.

There were no other positive findings ; all systems showed negative results.

X-ray Examination.—Straight radiography shows erosion of the anterior surfaces of the transverse processes and bodies of the lower cervical vertebræ on the left side.

All other radiological and special examinations were negative.

AT OPERATION.—It was decided to explore the swelling, and this was done in May, 1944. The mass was found to be irremovable, extending far downwards and medially, and being very fixed. It was firm but not hard in consistence, and of a whitish almost translucent colour. A piece of tumour was removed for examination and the wound closed.

Pre-operatively it was thought that the tumour would probably turn out to be a neuroma, possibly sarcomatous, originating from the sheaths of the plexus, most likely from C.5 and 6. The pathological report, however, was rather surprising. The tumour was reported as a ' chordoma ' : " The sections examined show the tumour to be composed of masses of cells, the characteristic feature of which is vacuolation. The nuclei are for the most part spherical. In places scattered nuclei can be seen in a mucin-like matrix. There is little intercellular substance. The appearances are those of ' chordoma '.

As the tumour was irremovable, it was decided to treat the case with deep X-ray therapy, and now, one year later, the tumour has diminished in size, although only slightly. The patient is in excellent health, eating well, putting on weight, and fully active. She states that she feels fitter than for some time past.

Discussion.—It is now accepted that chordomas arise from remnants of the notochord—the primitive skeletal axis, and consequently are most commonly found in those situations where small nodules of notochordal tissue remain. A full description of the notochord is to be found in text-books of anatomy and embryology, but it may be convenient to give here a brief account of it.

FIG. 292.—*Case* 3. Showing erosion of the transverse processes of C.6 and 7. The erosion of the anterior surface is not well seen in this view.

FIG. 293.—Same case. Lateral view, showing erosion of C.7 anterior half. This picture suggests that the tumour has originated in the body and made its way out anteriorly in the first instance.

The notochord (primitive skeletal axis) is developed from the anterior end of the primitive streak. Starting as a narrow process of cells, lying between the entoderm and ectoderm, as it elongates caudally it becomes incorporated in the dorsal wall of the archenteron, of which if forms a part. At a later stage, it is evaginated from the dorsal wall of the entodermal cavity and forms a rod of cells, lying in the midline, between the ectodermal neural canal and the roof of the primitive alimentary canal.

The paraxial mesoderm, lying on each side of the neural tube and notochord, eventually surrounds both these structures, and becomes separated into segments—the forerunners of the adult vertebræ, which are formed by the union of the cranial and caudal halves of adjacent segments. The part left between two developing vertebræ ultimately is the intervertebral disc.

Eventually we have the notochord passing along the whole length of the cartilaginous vertebral column from cranial to caudal end. At the cranial end it traverses the axis and runs upwards from the anterior border of the foramen magnum to the dorsum sellæ, stopping just behind the pituitary fossa. In its cranial course, as it runs between the cartilaginous precursors of the basi-occiput and basisphenoid, it dips ventrally and escapes from between the two parachordal cartilages and lies in the roof of the pharynx.

With the process of ossification the notochord disappears where it is enclosed in bone, and at the cranial and caudal ends of the vertebral column, where it is not so imprisoned, it usually disappears also, but it is in these sites that nodules of notochordal tissues may persist. Between the vertebral bodies the notochord persists as the nucleus pulposus of the intervertebral disc.

Chordoma is found, therefore, most commonly at the extremities of the vertebral column—in the sacro-coccygeal region, in the roof of the pharynx, and on the cranial aspect of the spheno-occipital area, as the notochord sometimes takes a loop upwards here as well as downwards to the pharyngeal roof (Bruce and Walmsley).

In other situations, chordoma is rare, and Bruce and Mekie, in 1937, reporting 2 cases of chordoma, traced in the literature 103 cases, of which only 11 were in the intermediate part of the spine, 6 of these being in the cervical region. In 1928 Cappell reported 3 cases of chordoma of the vertebral column, 2 in the cervical region, and 1 in the dorsal region. In this paper he gives an excellent résumé of chordomas in unusual situations. Harvey and Dawson, in 1941, out of a total of 240 cases, including their own and those obtained from the literature, give the following figures: Cranial 88, vertebral 30,

sacrococcygeal 122. In the case reported here the tumour is arising from the cervical region of the spine.

The presence of many remnants of the notochord in the shape of the nucleus pulposus of the intervertebral discs would lead one to suppose that here lies the origin of the tumour when it occurs in the vertebral column, and Ribbert's well-known experment of puncturing the intervertebral disc of a rabbit, with subsequent escape of the nucleus pulposus and the development of the typical physaliphorous type of tumour, would appear to support this hypothesis; it is thought now, however, that they arise in the bone rather than the disc (Harvey and Dawson). Cappell (1928) has shown conclusively in 2 cases of cervical chordoma that the tumour has originated in the affected vertebral body: "In both of the cervical cases it is clear that the tumour has originated *in* the affected vertebral body or on its anterior or posterior aspect rather than in the notocordal cells which are said to persist in the centre of the intervertebral discs." Complete sections of vertebral bodies are shown, demonstrating the affection of the bone by the tumour cells, with the intervertebral discs intact. The radiographs of this case (*Figs.* 292, 293), especially the lateral view (*Fig.* 293), show erosion and destruction of the anterior part of C.7 extending into the bone, whilst the intervertebral space maintains its integrity and the erosion is certainly not upwards or downwards through the cartilaginous plate from the space.

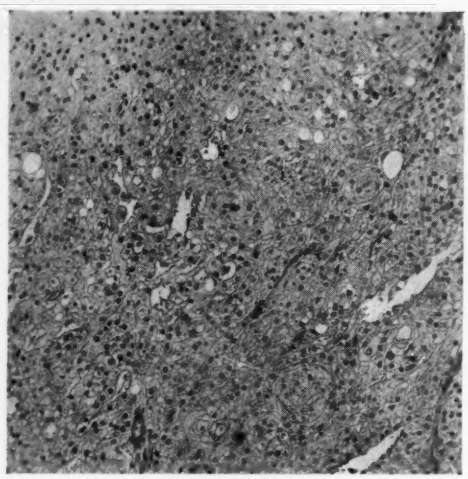


FIG. 294.—*Case* 3. Chordoma. Cells showing vacuolation. In the upper left-hand corner scattered nuclei are seen amidst mucinoid material. (× 100.)

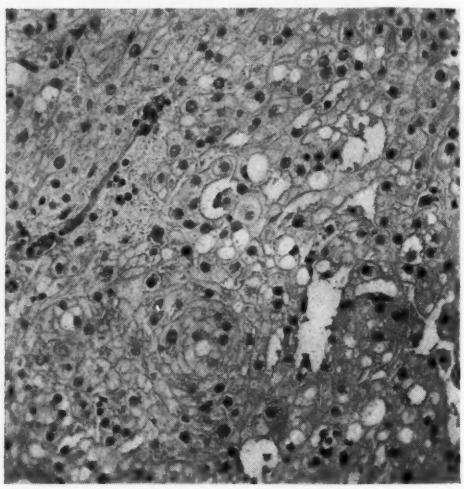


FIG. 295.—Same case. Showing the typical physaliphorous appearance. Signet-ring forms can be seen, also the oval and spherical nuclei. (× 400.)

PATHOLOGY.—The pathological features of chordoma are now well known; they have been fully described by Cappell (1928), Stewart (1926), and Harvey and Dawson (1941), among others.

The tumours are lobulated by fibrous septa—this varies in amount and sometimes is not well marked. The cut surface is of a whitish translucent nature, firm but not hard, with occasional areas of hæmorrhage where degeneration has occurred. There is a marked tendency to infiltrate and destroy bone.

Histologically, one of the most striking features is the vacuolation of the cells, which may take the form of a single large vacuole (*Fig.* 294), or perhaps two, displacing the nucleus to one side, giving a 'signet ring' appearance; on the other hand, there may be several smaller vacuoles giving the typical physaliphorous cell (*Fig.* 295). In other parts of the tumour the cells become so distended with mucin that they finally burst, mucinous material is liberated, and there results a mucinous mass containing scattered nuclei, collapsed cells, and cell remnants. This process usually occurs towards the centre of the lobule, and the gradual dissolution of the cell can be traced from the periphery centrewards.

The cell nuclei are mostly oval and spherical; in some areas where there is much mucinous material the nuclei have a crenated shrunken appearance, and in parts the nuclei themselves can be seen to contain mucin, giving a vacuolated appearance.

In their histology chordomas reproduce with a considerable degree of exactitude the stages in the development of the notochord (Cappell, 1938), from the cellular areas, simulating the appearances as seen in the early stages of the notochordal development, to the areas of intercellular mucinoid material arranged like a syncytium, representing the later stages of notochordal development and, indeed, the nucleus pulposus.

TREATMENT.—The treatment of chordoma is difficult. The ideal to be aimed at is complete extirpation, but very often this is impossible; deep X-ray therapy should then be tried and in some cases (as in this one) marked benefit results, although this is likely to be of only a temporary nature, and eventually, from encroachment on vital structures, death ensues.

I wish to express my thanks to Professor Sir John Fraser, Bt., for his permission to publish these cases, which were in wards under his charge.

Mr. D. B. Smith, of the Department of Clinical Surgery, has been responsible for the clinical photographs and photomicrographs, and to him also I am most grateful.

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PENETRATING WOUNDS OF THE CHEST

BY W. F. NICHOLSON, LIEUT.-COL., R.A.M.C.

THIS paper surveys 1639 penetrating chest wounds treated at a Chest Centre during the last three years. Half the period was spent in the Middle East (Nicholson and Scadding, 1944) and half in the Central Mediterranean Forces. For short periods, such as at Alexandria during the retreat to El Alamein, and at Naples at the Cassino offensive, the Centre has been so near to the front that casualties could be evacuated directly to it and the primary toilet of the wound undertaken. But more frequently they would arrive two to four days after wounding, till the battle moved away and the winter rains came; under such conditions they often did not arrive for three or four weeks. But finally the majority of penetrating wounds did reach the Chest Centre.

INCIDENCE

In summarizing the incidence of chest wounds, Carter and De Bakey (1944) state that they occur in a ratio of about one to four among those killed on the battlefield and about one to twelve among the wounded. The distribution of wounds of entry in 500 consecutive penetrating chest wounds from the summer battles in Italy has been plotted, as shown in *Figs.* 296, 297. There is a marked absence of wounds over the heart and great vessels, and relatively fewer entries in the left lower chest than in the right. The deductions are obvious; that cardiac and mediastinal wounds are often fatal, and that thoraco-abdominal wounds on the left have a higher early mortality than those on the right.

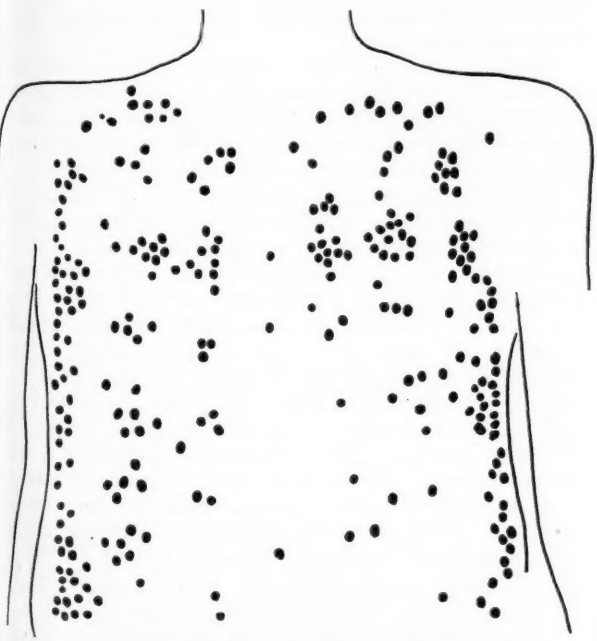

FIG. 296.—Entry wounds—anterior distribution.

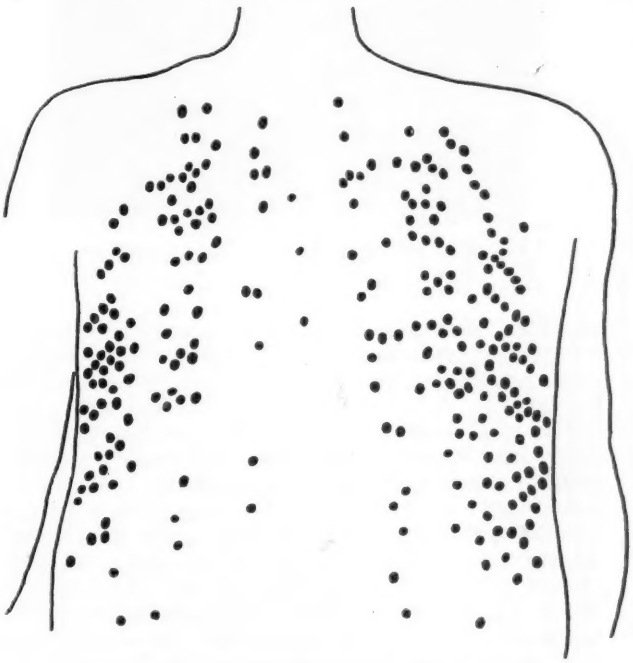

FIG. 297.—Entry wounds—posterior distribution.

CHARACTER OF WOUNDS

Lung.—Some pulmonary contusion is always caused by a penetrating wound of the lung. Sometimes the path of the missile is demonstrated in a radiograph, in which it appears as a solid or air-containing track. These missile tracks, which have been well described by Hodson (1944), are chiefly of radiological interest; to the clinician they may serve as a rough guide to the degree of healing of the lung. When the track is healed it appears as a dense narrow band, connecting the sites of entry and exit, or the entry with the retained foreign body. *Fig.* 298 shows a healing track connecting entry and exit

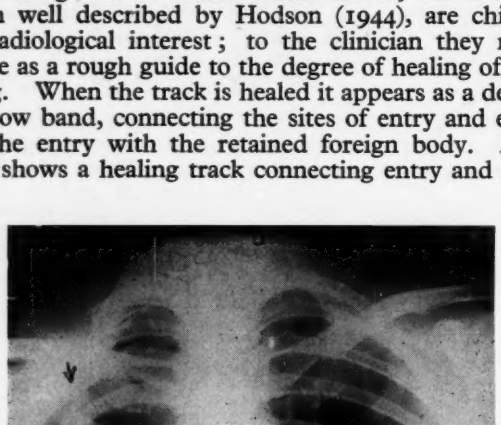

FIG. 298.—Healing track, partly solid and partly containing air.

wounds. However, in severe pulmonary contusions it is rare to see these tracks, for the radiological picture is blurred by the extent of the pulmonary hæmatoma. The presence of a pulmonary contusion more than any other factor, renders patients with chest wounds unsuitable subjects for radical primary surgery. The embarrassment due to a hæmothorax can be relieved by aspiration and the blood-loss made good by transfusion, but a wet lung due to a pulmonary hæmatoma remains a danger. During a long anæsthetic there is a risk of aspirating blood into the opposite lung; this danger is increased when the contused lung is handled. Moreover, the lung itself is not in a condition fit for surgery, unless an unnecessarily radical operation such as lobectomy of the contused lobe is undertaken. A contused lung will not hold sutures well and early operations on such damaged lobes nearly always fail to prevent subsequent infection. The majority of pulmonary hæmatomata resolve spontaneously; a few pass on to pneumonia; fewer still to an abscess.

Atelectasis is frequently associated with pulmonary contusion, especially if a hæmothorax is also present. The majority of these collapsed lobes expand spontaneously with the help of simple breathing exercises; in resistant cases, if there is sputum, postural drainage is of value. Only very rarely, four or five times in the whole series, has a bronchoscope been passed on such patients, and then not until simpler measures had been given a trial for two or three weeks. Atelectasis in a lower lobe due to aspiration of blood from a wound in an upper lobe usually clears up much sooner than a collapse in a wounded lobe; as would be expected, for it is simply a temporary block in the bronchus of an otherwise healthy lobe.

Blast injuries may complicate the issue in all chest wounds, but it is outside the scope of this paper to discuss the condition. In the majority of cases, by the time the patient reached the Centre, symptoms due to blast were minimal.

Pleural Cavity.—

Pneumothorax alone is relatively infrequent, though in nearly all hæmothoraces there has been an initial pneumothorax. When a pneumothorax is present without effusion, it has been left to be absorbed spontaneously. The lung is thereby given a rest and rapid spontaneous re-expansion is the rule. If it were certain that the penumothorax was only due to a sucking wound with no pulmonary contusion, it would be more logical to aspirate it as soon as possible; but in practice it is usually not possible to exclude a lung contusion.

Tension pneumothorax is relatively rare; 24 cases in the whole series (1·5 per cent). It is always serious, both immediately and remotely. Ten of these patients died later from sepsis associated with bronchopleural fistula.

Hæmothorax is the major complication of penetrating wounds, embarrassing respiration in the early days and favouring infection in subsequent weeks. Its frequency is shown by the 1027 cases which occurred in this series (62·6 per cent). Of these, 718 remained uninfected and fluid; 217 were infected and fluid; and 92 were clotted or multilocular. Three-quarters of the last group were infected and they are considered later. In the whole group of 1027, there were 229 empyemata (22·3 per cent). Infection is therefore still the major factor in the management of a hæmothorax. The advocates of aspiration have always stressed that the sooner the blood is removed from the pleural cavity and the lung allowed to expand, the less chance of infection; and the more localized such infection will be if it occurs. Air replacement is harmful because a large pleural space remains open to infection; moreover, it does not stop bleeding from the chest wall, which was the site of bleeding in half the cases of secondary hæmorrhage, a complication which though uncommon is worth further consideration.

Secondary Hæmorrhage.—In those cases in which the bleeding came from the lung, in three it appeared that a retained foreign body was the cause; in the fourth there was such a large rent in the lung that it is very doubtful whether a pneumothorax would have prevented further bleeding. It is fortunately rare for further bleeding to occur into the pleural cavity after the first twenty-four hours. There were only 8 such cases.

Case 1.—Penetrating mortar wound, entry just below the middle of the right clavicle, the fragment being

retained in the right upper lobe near the posterior end of the oblique fissure. No hæmothorax appeared till the tenth day, when he became febrile and developed a partly clotted hæmothorax.

Another case was of the same type; two others occurred three and eight days respectively after the last aspiration. The other four, however, were precipitated by aspiration, for in each case a sudden increase in the size of the hæmothorax was apparent two to three hours after the completion of this operation.

Case 2.—Penetrating mortar wound, entry in the seventh space in the left posterior axillary line, the fragment being retained just in front of the seventh intercostal vessels. The hæmothorax was first aspirated six days after the injury, when 600 c.c. of thick blood containing scanty pus cells and *Staph. aureus* was aspirated, penicillin being replaced. On the tenth day 850 c.c of pale sanguinous effusion, containing pus cells but sterile, was aspirated and penicillin replaced again. Towards the end of the operation he began to cough, but otherwise the aspiration was uneventful. He complained of no " tightness " in the chest and no air was replaced. A quarter of an hour later he collapsed and soon signs of a large hæmothorax were present. Two pints of fresh blood were immediately aspirated and even then it was obvious that more remained. After a blood transfusion a thoracotomy was performed, which showed the pleural cavity to be full of blood, both liquid and clotted; the bleeding came from the seventh intercostal artery, on which the foreign body was lying. He made an uneventful recovery and returned to duty two months later.

There is, therefore, an extremely slight risk of starting bleeding by aspiration; this can be minimized by slow evacuation of the blood from the pleural cavity, especially if the aspiration is performed under general anæsthesia, when the patient's sensations are not available as a guide in assessing the intrapleural pressures. Rapid aspiration under these conditions may leave a dangerously negative pressure which encourages further bleeding. When secondary hæmorrhage does occur it is probably safer to operate early rather than to wait for further bleeding before abandoning conservative treatment, as the following case illustrates.

Case 3.—Penetrating shell-wound, entry 2 in. to the left of the sternum in the fourth interspace. Six days after injury, 900 c.c. of blood and about 300 c.c. of air were withdrawn and the wound sutured under pentothal anæsthesia. One hour later he had gross surgical emphysema with a bulging left chest. An intercostal catheter was introduced to relieve the tension pneumothorax, air and blood escaping in considerable quantity. He was so much better the next day that the catheter was removed. Further aspirations were performed on the twelfth and sixteenth days, by which time it appeared that the chest was nearly dry. On the twentieth day a large hæmothorax appeared again and a thoracotomy was performed. There was severe bleeding from the hilar region of the left upper lobe, but unfortunately the adhesions were now so dense that they could not be separated quickly to enable the lobar pedicle to be grasped. The patient died before the bleeding could be controlled. A shell splinter had penetrated the pulmonary artery to the upper lobe.

Here a lobectomy would have been easier at the time of the first hæmorrhage before the adhesions were so dense.

CLOTTED HÆMOTHORAX

The main features of this condition have already been described (Lush and others, 1944), so that here only one or two additional observations will be recorded. Clotting is twice as frequent on the right as on the left side, for there were 61 right and 32 left loculated or clotted hæmothoraces. Though a hæmothorax is commoner on the right owing to the greater early mortality of left-sided wounds, yet there is a relatively increased incidence of clotted right hæmothorax, for only 56 per cent of all fluid hæmothoraces were on the right and 44 per cent on the left. This apparent tendency of the right

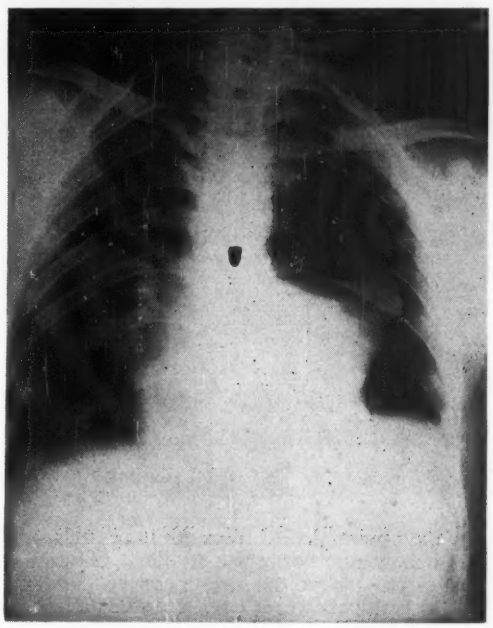

FIG. 299.—*Case* 4. Bullet in the spine. Left hæmopneumothorax, with complete atelectasis.

hæmothorax to clot may be due in part to associated liver wounds, for clotting seems to be favoured in these cases. There is no doubt that some clots are absorbed slowly; but absorption of large clots usually leaves considerable pleural thickening with limitation of movement. This is not surprising because of the frequency of low-grade infection in these cases. The tragedy of conservative treatment when generally applied is that many cases will ultimately develop an empyema at a time when the chest is already frozen by thickened pleura. Though penicillin may sterilize many of the loculi in a clotted hæmothorax, it does not always reach the centre of the fibrin clots, which remain a source of infection. Evacuation of clots, therefore, decreases the risk of late infection. The obliteration of the dead space remaining when the clots have been removed is effected by stripping the membrane from the surface of the lung, which is then expanded immediately with positive pressure anæsthesia. Organisms are frequently grown from this sheet of organizing fibrin even when they are absent from the clot, as the following case illustrates.

Case 4.—Entry wound over the left shoulder, with a bullet retained in the body of the seventh dorsal vertebra. Complete collapse of the left lung with an uninfected hæmothorax. Two weeks later a thoracotomy was performed for the removal of the bullet; the lung was decorticated in order to allow it to expand at once, though here the indication for the thoracotomy was the retained bullet. A pure growth of *Staph. aureus* was obtained from the membrane peeled from the lung surface, though the rest of the hæmothorax was sterile. The radiographs (*Figs.* 299, 300) show the pre-operative condition and *Fig.* 301 the result six weeks later when he left the hospital for convalescence.

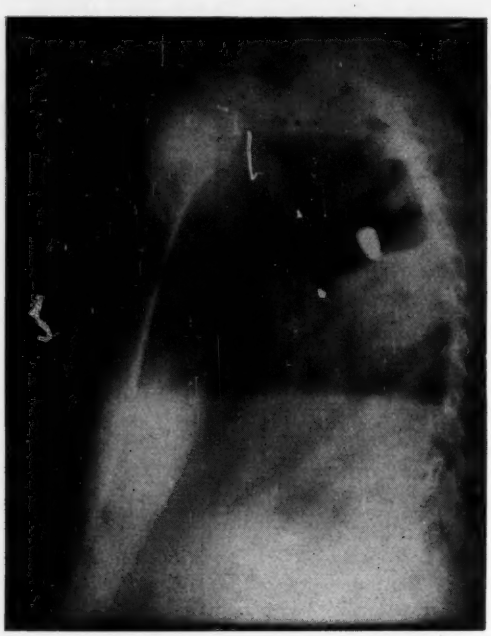

FIG. 300.—*Case* 4. Left lateral radiograph showing bullet in the spine.

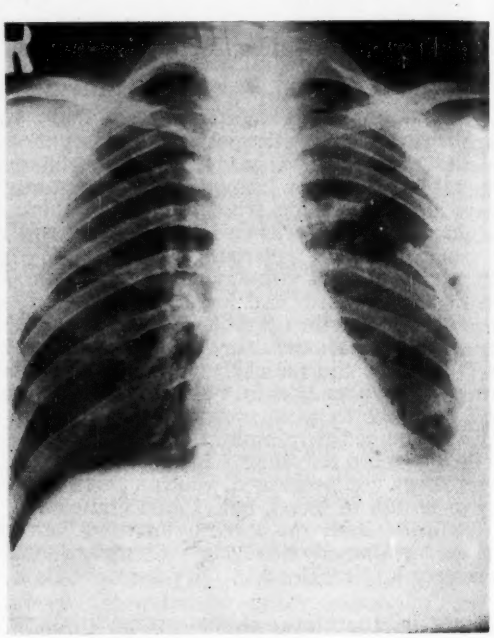

FIG. 301.—Same case. Result six weeks after decortication.

Decortication not only allows the lung to expand early, but also removes more infected fibrin. If an intrapulmonary missile has to be removed, or a bronchopleural fistula needs repair, suture of the lung is much easier after this membrane has been stripped away from the surface of the visceral pleura.

Case 5, with a penetrating mortar wound, a small fragment being retained in the left upper lobe. He had three aspirations with penicillin replacement before admission to the Chest Centre. By then the hæmothorax was clotted and infected with *Staph. aureus*. Radiographs (*Fig.* 302) showed a total clotted hæmopneumothorax. Thoracotomy three weeks after the injury, with evacuation of all blood-clot and removal of the foreign body, decortication of both lobes and immediate expansion of the lung. A course of parenteral penicillin was given for the first five days after operation, the drainage tubes being removed in three days when radiographs had shown the lung to be expanded and no appreciable fluid remaining. He made an excellent recovery, returning to Base duties six weeks after his operation. The blood, the clot and the membrane peeled from the lung in this case all grew *Staph. aureus* on culture. *Fig.* 303 shows the result six weeks after operation.

Such a case with conservative treatment nearly always forms an empyema; even with a limited operation of clot clearance without decortication there is still some risk of an empyema developing. This patient illustrates what can be achieved with radical surgery in these cases. In those who developed an empyema there was frequently an anterior pleural pocket that required separate drainage. In recent operations two anterior intercostal drains have been used, in addition to a posterior drain in the ninth space. The anterior drains are usually placed in the fifth space in the anterior axillary line and in the second space in the mid-clavicular line when the upper lobe is completely collapsed. With this technique there is a better chance of the upper lobe expanding completely, without leaving a residual anterior pleural pocket to become infected.

EMPYEMA

The empyema rate in penetrating chest wounds should vary with the location of the Chest Centre; the farther back the Centre is placed, the larger the proportion of empyemata. In actual practice this selection of septic cases for the Chest Centre seems to have made no difference to the empyema rate in hæmothoraces, which remains the same now with the battle far away as it was when patients arrived within twelve hours of wounding. In the Middle East the empyema rate in hæmothoraces was 33 per cent; in the Central Mediterranean Forces it fell to 25 per cent in the first three months, and has since remained at 17 per cent. (The empyema rate in all penetrating wounds of the chest is now 12 per cent; the 17 per cent incidence refers to hæmothorax only). In the first three months in the C.M.F. penicillin was injected into many of the infected hæmothoraces, but it was not used as a routine. In the last nine months it has been the rule to replace 30,000 units of sodium penicillin in 50 c.c. of saline

at the end of an aspiration; moreover, this practice has been started in the forward units. Some of the credit for the fall in the empyema rate must therefore be attributed to penicillin; for the rest, the forward and base surgeons must share the honours, the former for his excision of the parietal wound and aspiration of the hæmothorax, and the latter for the evacuation of clotted hæmothoraces, removal of intrapleural foreign bodies, and re-expansion of the lung. It

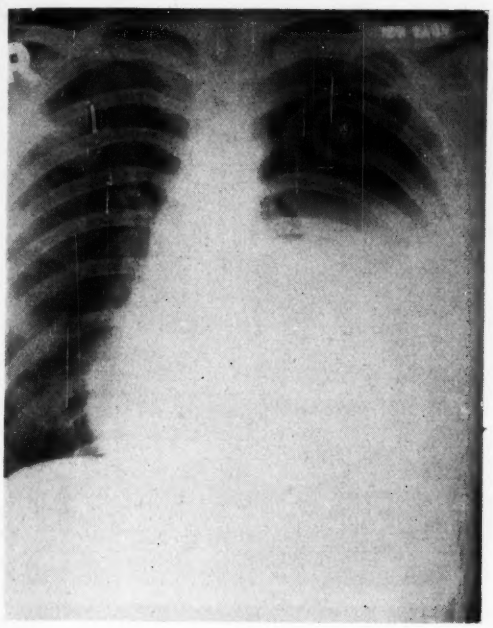

FIG. 302.—*Case* 5. Left infected hæmopneumothorax; atelectasis of left lung.

is here that decortication may have prevented empyemata in some of the infected clots, by rapid obliteration of the pleural dead space. Another factor which is not always appreciated is that penicillin has done more than anything else to encourage early aspiration of the hæmothorax, since it cannot be introduced into the pleural cavity without an aspiration being performed.

Does the intrapleural use of penicillin result in fewer drainage operations for the infected hæmothorax? The test is whether pus, once present, will disappear and the lung expand completely. It is not enough to say that penicillin will sterilize many infected hæmothoraces; it undoubtedly will do so, but in this series there were 15 such infected liquid hæmothoraces which settled without suppuration in the days before penicillin. There was, however, only one case in which an empyema was treated by aspiration and settled completely before penicillin was available. There have been several small empyemata which have settled completely with aspiration and penicillin replacement. The presence of a bronchopleural fistula or fibrin clot, however, will usually doom conservative treatment to failure; and even if a 'cure' is obtained, where fibrin is present in much quantity, the functional result is poor; gross pleural thickening and limitation of movement, even scoliosis in some cases, seems to be the price paid for avoiding orthodox drainage.

CHRONIC EMPYEMA

There are five factors in war wounds of the chest which favour the development of a chronic empyema:—

1. The wound of the lung may produce a permanent scar, with inability of the affected lung to expand.
2. Prevalence of *Staph. aureus* infection, an organism which produces no fibrinolysin.

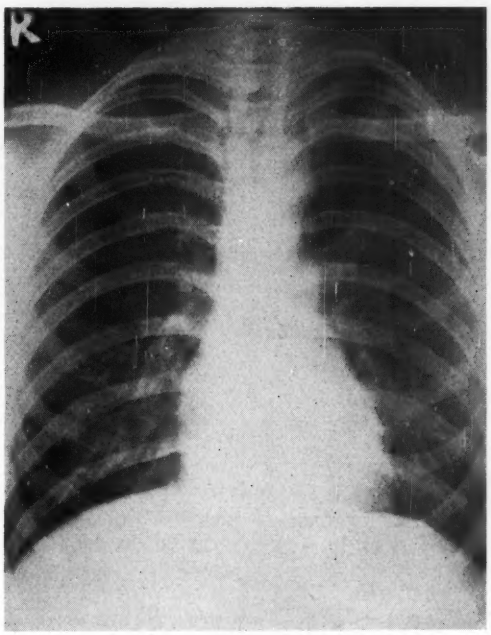

FIG. 303.—Same case. Result six weeks after decortication.

3. Retained foreign body.
4. Bronchopleural fistula.
5. Fibrin deposit on the visceral pleura, which is very tough and unyielding.

In trying to prevent chronic empyemata, clearly nothing can be done to remove the first factor. Penicillin helps to prevent the second. The third is a purely surgical problem; if the foreign body is intrapleural or in direct contact with the pleural space through a bronchopleural fistula it must be removed. If large and deep in the lung it may still be delaying expansion of a lobe. The controversy will be about the fourth and fifth. Many bronchopleural fistulæ will close spontaneously; some take a very long time, during which the patient is continually in danger of aspirating septic material from the empyema into the bronchial tree. The longer the fistula remains, the tougher the ensheathing membrane on the surface of the lung becomes; a stage is then reached, sometimes not till after four or five months, when the fistula closes but the lung fails to expand. Thoracoplasty may ultimately be the fate of these cases. It is in the total empyema in which there is no sign of expansion of the lung two to three weeks after preliminary drainage that there is a place for decortication, repairing any fistula that may be present and expanding the lung immediately at operation. The advantage of this method is well illustrated by the following case.

Case 6.—Left thoraco-abdominal wound, with a left hæmothorax and a perforation of the stomach. By the time he reached the Chest Centre, one month after wounding, there was a total empyema containing much infected clot. This was drained by rib resection, the clots being mopped out. Two weeks later, as there was no sign of expansion, a decortication of both lobes was done. Although the membrane was very dense, once the layer was found decortication was easy and the lung expanded with pressure. The drainage tube was replaced, being made airtight, and an intercostal tube was placed in addition in the fourth space in the anterior axillary line. A course of parenteral penicillin was given. These drains continued to drain small anterior and posterior pleural pockets, till eight weeks after the operation when the anterior sinus was completely healed; a small postero-basal sinus remained, a tube track only. The lung was otherwise fully expanded and the patient in excellent health. *Fig.* 304 shows the collapse persisting two weeks after instituting drainage, and *Fig.* 305 the result two months after decortication.

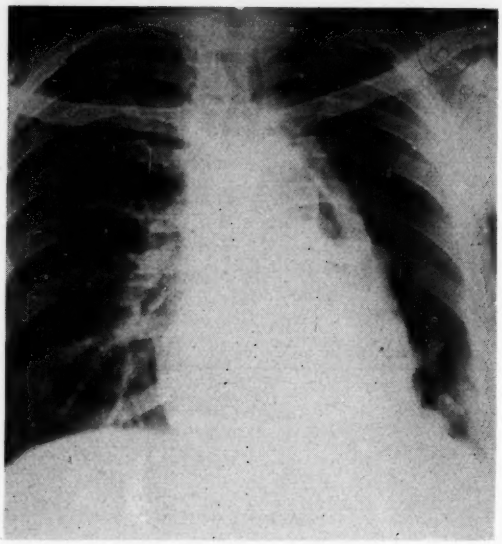

FIG. 304.—*Case* 6. Total empyema, two weeks after drainage.

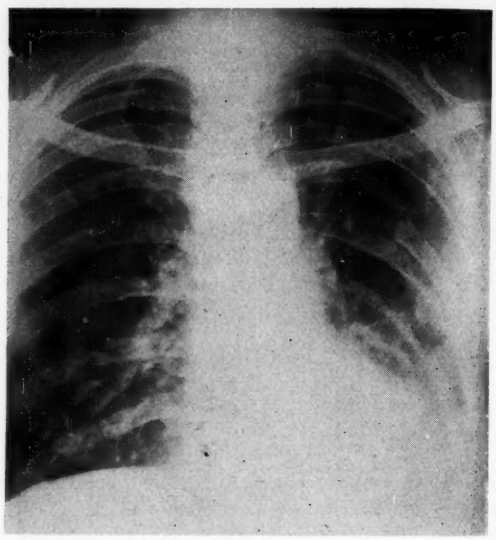

FIG. 305.—Same case, two months after decortication.

In this case drainage was necessary, but expansion of the lung was hastened. In the next case to be recorded, prolonged drainage was avoided by early operation.

Case 7.—Wounded Dec. 12, 1944, entry in the sixth space in the anterior axillary line on the left, the fragment perforating the upper lobe and lying in the neck. He was aspirated five times before arriving at the Chest Centre three weeks later. He then had a loculated pyothorax, with thin pus in an anterior loculus, from which only coliforms and diphtheroids were grown. He had a swinging temperature to 102° nightly. Thoracotomy one week later and evacuation of clots and pus; the upper lobe was adherent at the wound of entry, but otherwise both lobes were completely collapsed. Easy decortication and complete expansion. Temporary intercostal drainage to second and sixth spaces anteriorly, and in the ninth space in the posterior axillary line. The anterior drains were removed on the fifth day and the posterior on the ninth, when the foreign body was removed from the neck. The fever settled promptly and he made an uninterrupted recovery, being fit for convalescence six weeks later. *Fig.* 306 shows the pre-operative condition, *Fig.* 307 two days after operation, and *Fig.* 308 four weeks later. *Fig.* 309 gives the temperature chart.

One criticism of the method is that there is a possible danger of insufflating septic material into remote bronchioles when pressure is applied by the anæsthetist; though there may be a similar danger of sucking debris into the depths of the lung when air is removed from the pleural cavity with a pneumothorax apparatus, since the same difference in pressure must exist if the lung expands in each case. This is not a serious danger, for in most of these cases the lungs are not 'wet' and are in no way comparable to the septic lungs of civilian practice. Routine post-operative bronchoscopy showed so little secretion that it was considered unnecessary. In a few cases sputum has been excessive, and operation on this account has been contra-indicated.

Another criticism is that a wounded lung requires time to heal, and it may be better to leave it collapsed until healing is complete. The experimental work of Montgomery (1943) suggests, on the contrary, that the process of repair in lung wounds will be quicker and more complete in a fully expanded lobe. Unfortunately in so many of these cases it is the lower lobe which bears the burden, even when the wound has been of the upper lobe alone. Often the upper lobe is expanded, but the hæmothorax has prevented the lower lobe from expanding; so that the healthy lobe remains collapsed till the clot is removed. But even with a wounded lobe, by the time the decortication is done, not usually till three to four weeks after wounding, the wound track will not be disrupted by the pressure necessary to expand the remaining lung. On many occasions a waist-like constriction corresponding to the healed track appears in the wounded lobe when it is re-expanded.

A bronchopleural fistula will not be made if the entry and exit wounds in the lung are duly respected; stripping should be very gentle here, and if firmly adherent it is much better to leave this portion unstripped rather than run the risk of opening up a fistula which has recently become sealed. The

fear of disseminating infection and causing a septicæmia has been exaggerated; it may be that the patients have been protected by chemotherapy, for it is the routine to give a five-day course of parenteral penicillin in these cases. There is no evidence that infection has ever been spread by decortication.

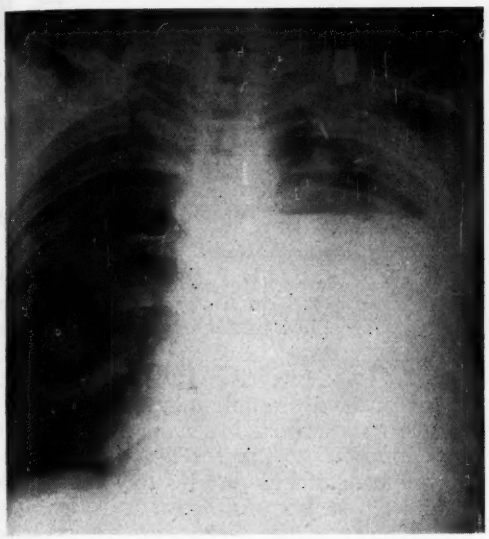

FIG. 306.—*Case 7.* Total loculated pyothorax. The large foreign body is in the neck.

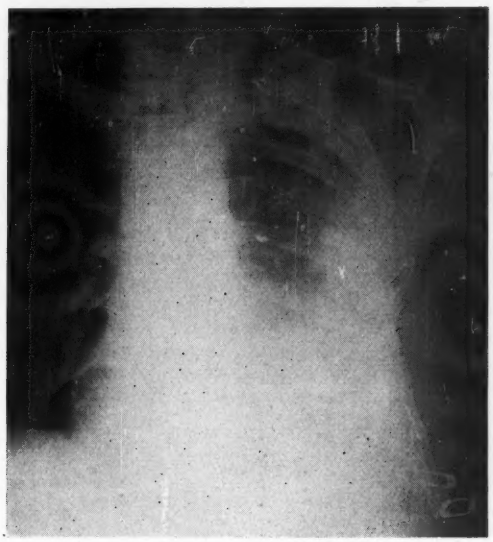

FIG. 307.—Same case, two days after decortication; the drains *in situ*.

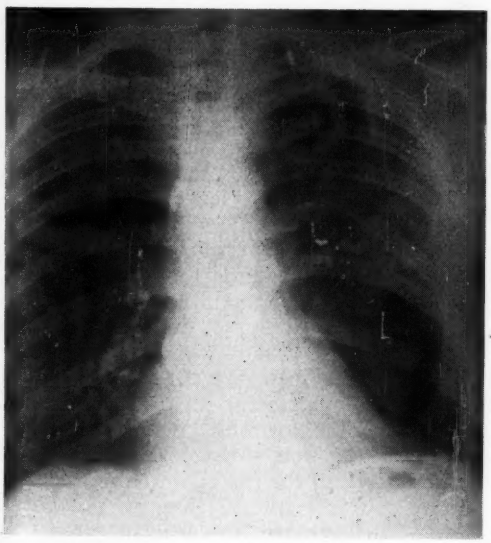

FIG. 308.—Same case four weeks after decortication.

Fig. 310 is a photomicrograph of the membrane peeled from the lung. As organization of the membrane advances it becomes increasingly difficult to separate it from the visceral pleura, the optimum time for the operation being within the first two months.

Finally, although decortication may expand the lung, it may leave pleural pockets where pus accumulates if an empyema forms. This is true; unless complete expansion occurs such pockets may remain. They are usually small and situated commonly at the apex, at the anterior costophrenic angle, and at the base. Even if one or all of these pockets require drainage, it is still true that the patient may be more fortunate than he would be waiting for spontaneous expansion to occur in a total empyema.

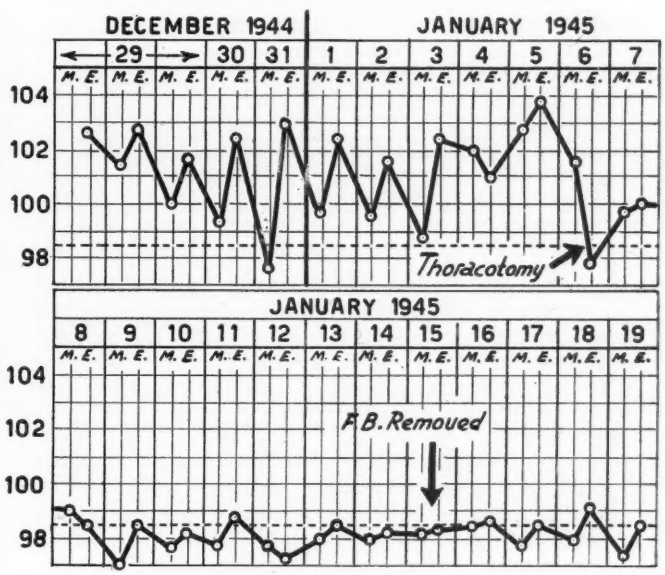

FIG. 309.—Same case. Temperature chart.

THORACO-ABDOMINAL WOUNDS

Here a definition is necessary. Only wounds which have some obvious sign of pleural penetration will reach the Chest Centre; the others will go to the general surgeons. Classified as thoraco-abdominal are all penetrating wounds of the chest in which the missile has penetrated the abdominal cavity, whether it causes symptoms or not. Hence many cases were only diagnosed as thoraco-abdominal

after fluoroscopy, when the foreign body was seen in the abdominal cavity. Altogether there were 164, of which 101 were on the right and 63 on the left. Intervention by the forward surgeon was more often required in left-sided wounds, including splenectomies, sutures of stomach, and repair of diaphragm. On the right side conservatism in liver injuries is more common than operation; in those cases in which operation has been performed, it usually consisted of a laparotomy for severe intraperitoneal hæmorrhage. The transthoracic approach to the liver has not been much favoured by British forward surgeons, unless a sucking wound of considerable size has pointed the way. Subphrenic abscesses have been encountered in the proportion of 13 on the right to 7 on the left. It is unusual for these abscesses to show a fluid level, or for much help to be afforded by radiographs; a raised diaphragm so often accompanies wounds in the lower chest that it may have no other significance. Bile must often escape into the pleural cavity in right-sided wounds, but fortunately an established cholethorax is rare, for in most cases the fistula soon closes. In 6 cases bile continued to accumulate in the pleural cavity and they all become infected with coliform organisms, forming empyemata. There were two cases of bronchobiliary fistula, in which large quantities of bile were expectorated. One patient, with a perforating thoraco-abdominal wound, started to cough up bile for the first time after twelve days and continued to do so for two weeks, when the fistula closed. In the other, 12 oz. of bile were coughed up daily; here there was a large foreign body deep in the substance of the liver. He died of toxæmia from continued sepsis before the foreign body could be removed, the fistula having persisted for six weeks without showing any signs of spontaneous closure. Many small tears of the left diaphragm have been repaired by forward surgeons; five left-sided herniæ were repaired at the base; one right liver hernia was not submitted to operation, since it was not increasing and the patient was well. The mortality in this group is high, even at the base; there were 11 deaths in the left-sided and 12 in the right-sided wounds, a mortality of 22 per cent.

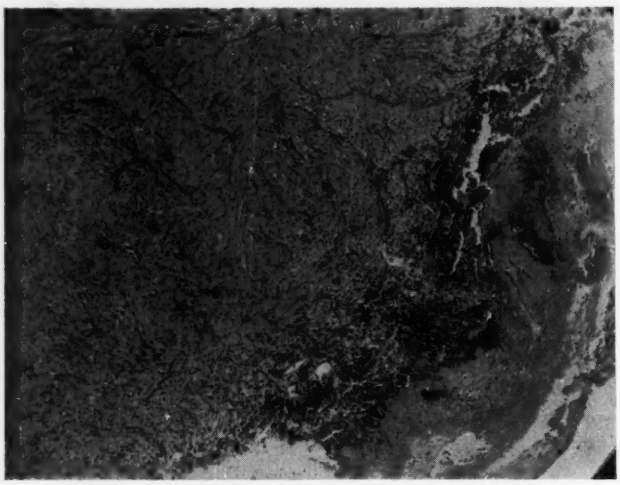

FIG. 310.—Photomicrograph of the membrane removed by decortication. *Histological report by Major G. J. Cunningham, R.A.M.C.*: The progressive organization of the membrane is well seen. There are three areas:—

1. A pale rather homogeneous layer on the right, the surface facing the pleural cavity, which consists of fibrin.
2. A larger area on the left and occupying most of the picture, consisting of well-developed fibrous tissue.
3. An intermediate zone, darker in colour, which shows vascular congestion and the presence of large numbers of histiocytes, containing yellow pigment. This pigment was assumed to be bilirubin, as it gave a negative iron reaction. The section was taken from a patient with a thoraco-abdominal wound, with a bile-stained loculated hæmothorax; the fibrin forming the outer part of the membrane was consequently stained yellow by absorption of bilirubin. The picture gives an idea of the extent of the fibrous organization and emphasizes the importance of early operation, if decortication is to be successful.

RETAINED METALLIC FOREIGN BODIES

Intrapleural.—A foreign body free in the pleural cavity commonly causes an empyema; there were 26 empyemata in 39 patients with such foreign bodies. There is a clear indication, therefore, for early removal of such fragments. If the associated hæmothorax is uninfected, penicillin replacements after aspiration may prevent infection during the time occupied in evacuation to the base and in localization of the foreign body. But the delay in removal should not be too great, though hasty operation in an unfit patient is even more harmful. These are the foreign bodies which will most frequently be removed by the forward surgeon at the primary operation.

Pulmonary.—Several years must elapse before a correct assessment of the danger associated with a retained foreign body in the lung can be made. That there is a real danger of infection and late hæmoptysis is evident from the experience of many surgeons who have seen such patients in the years between the two wars, but the frequency of such complications can only be properly assessed by a combined study of the later histories of those men who still retain their foreign bodies. The policy has been to remove large pulmonary foreign bodies (1 cm. × 2 cm.) wherever situated; to remove small (1 cm.) fragments if in close proximity to mediastinal or hilar structures; and to leave small peripheral or 'safe' foreign bodies unless causing symptoms. 'Safe' here is a relative term; it implies only that there are reasonable grounds for assuming that the first hæmoptysis will be small and not immediately fatal, as might be the case with a foreign body near the hilum. At first it was felt that there was considerable risk of infecting the pleural space; to prevent this the peripheral missiles were removed in two stages after forming pleuropulmonary adhesions. This is not satisfactory. It is always more difficult to find the metal, and a more extensive resection of rib is required than in the one-stage operation. Furthermore, the fear of pleural sepsis was greatly exaggerated. Although organisms have been found on culture in 17 out of 31 foreign bodies removed across a clean pleural cavity, if the operation is done at the correct time there is little fear of an empyema developing. Only one of the above cases developed a localized empyema, and here the operation was done too early, for the pulmonary hæmatoma had not completely resolved and it was difficult to suture the lung. Though adhesions resulting from a hæmothorax may often help to limit infection, the most important single factor in avoiding infection is to delay the operation till the

pulmonary hæmatoma around the foreign body has completely resolved. In the majority of cases, therefore, an interval of three or four weeks should elapse after the injury before the removal of the missile. Some missiles may need removal at an earlier date on account of sepsis or hæmoptysis, but in general the lung requires a rest before it is fit for surgery. It may be impossible to suture lung which has been recently contused; when the hæmatoma has subsided the foreign body may be safely extracted and the lung sutured. In the other 30 cases in which intrapulmonary fragments were removed, infection of the pleural space was already present at the time of operation. Two patients who had moderate-sized foreign bodies had late hæmoptysis, one year and three months respectively after wounding; the fragments were removed in each case at this stage. In 8 cases a lung abscess has been due to a retained foreign body, but only in 1 was this a putrid abscess; in 3 instances a local pneumonotomy for drainage and removal of the fragment was possible, without opening the general pleural cavity; 1 was associated with a total empyema; the other 4 were little more than benign foreign-body abscesses and caused no further trouble after the fragment was removed.

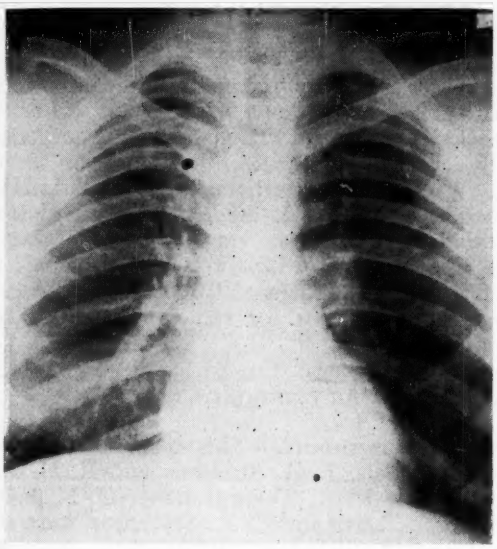

FIG 311.—*Case* 8. Foreign body in the pericardium, two months after injury. (The other fragment is in the right upper lobe).

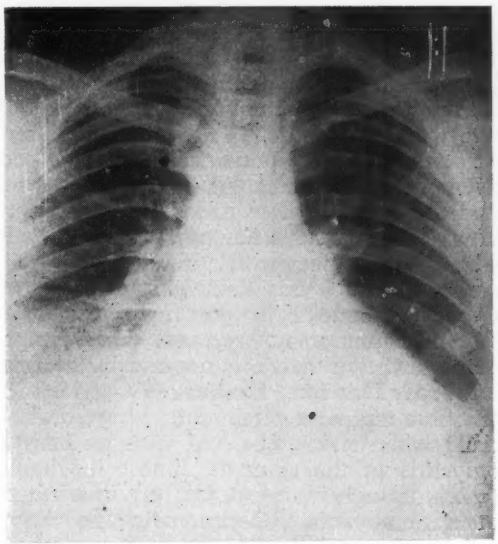

FIG. 312.—Same case, ten weeks after injury, during the first attack of pericarditis.

Pericardial.—Fragments lodged in the mediastinum have been removed when large and near the œsophagus or great vessels. Smaller pieces may be left, usually without disability, with the exception of fragments in, or adjacent to, the pericardium. Even tiny fragments in this situation may cause effusions in the pericardial sac, of which the following is a typical example :—

Case 8.—Had multiple mortar wounds with a right hæmothorax. There were two small retained fragments in the chest, one in the right upper lobe and the other in the anterior part of the pericardium. There was no cardiac abnormality at first, so that after the hæmothorax had been evacuated he went to the Convalescent Depot. Ten weeks after wounding he came up to the hospital for a routine review and returned to convalescence for another month. One week later he reported because he had developed tachycardia and dyspnœa with retrosternal pain. On examination he had low fever, the pulse was regular at 140, with distant heart-sounds, a scarcely perceptible apex beat, and there was a slight increase in the cardiac dullness. There was no friction. Radiographs confirmed the increase in the heart shadow, showing a pericardial effusion. In four days the pain and tachycardia disappeared and he seemed well again. Two weeks later he had a similar attack, lasting four or five days. Electrocardiographs now showed normal QRS complexes and simple inversion of the T-waves in all leads, described by Paul Wood (1937) as the T2 pattern. In consultation with Brigadier Boland and Lt.-Col. Paul Wood, it was agreed that the foreign body was causing pericardial irritation and that it should be removed. The sixth rib on the left side was divided just lateral to its junction with the cartilage and the sixth costal cartilage divided half an inch from the sternum, the rib and cartilage being turned down as a flap hinged on the sixth intercostal muscles. The pleura was so adherent to the pericardium that it could not be reflected, so a transpleural route was adopted. The foreign body lay in a little pocket of dirty granulation tissue in the fibrous pericardium; the pericardial sac was not opened. Coliform bacilli were grown from the fragment on culture. He made an uninterrupted convalescence and has had no further attacks of tachycardia. *Fig.* 311 is a radiograph two months after the injury, before he had shown any pericardial symptoms. *Fig.* 312 is a radiograph taken two weeks later during the first attack of acute pericarditis.

This patient illustrates the syndrome of recurrent pericarditis from irritation by a foreign body. Pericardial effusions have been caused by other foreign bodies, which, though not in the pericardial sac, were in contact with it during some phase of the heart cycle. Four of these were in the cardiac surface of the lingula segment of the left upper lobe; in each case there was evidence that the fragment had impinged on to the adjacent pericardium, which

showed a local inflamatory reaction. Two other fragments, which were considered to be in the pericardium, were embedded in the myocardium, but so near its surface that they were in contact with the pericardial sac. It is the fragment in direct contact with the pericardial sac which may cause recurrent attacks of pericarditis; as these pieces can be removed with very little risk, it is well that operation should be considered as soon as there are signs of recurrent irritation of the pericardium. The initial reaction of the pericardium to the wound is not an indication for operation, but another attack of pericarditis shows that the fragment is causing trouble and it should be removed during a quiescent phase, when the attack has settled. It is possible that pericarditis would not recur after the second or third attacks, but since the foreign body is a proven menace, and as the operation in itself is not dangerous, it is wiser to remove the fragment once it is certain that it has caused trouble. Pericardial or juxta-pericardial foreign bodies are removed with much less risk than are those which are deeply embedded in the myocardium; forfunately the latter do not seem to cause symptoms so often and their removal is not usually necessary.

Vertebral Foreign Bodies.—A serious complication is a fragment retained in a vertebral body, especially when it is associated with an empyema. Osteomyelitis of the spine is almost inevitable in such cases, though by no means certain when there is not an empyema. Occasionally the fragment can be removed easily by the transpleural route during a thoracotomy for pleural toilet or drainage; but it more often needs a second planned operation after the empyema has been drained. Then an extrapleural approach, with resection of two ribs and mobilization of the bundle, is satisfactory. In the after-care, involving a plaster bed and continued drainage of the pleural cavity, a balance must be struck between recumbency and the optimum position for draining the empyema; this can usually be effected by raising the head of the bed.

REHABILITATION

Breathing exercises, with control of the good side, are started early. They may do harm in infected cases and so should be postponed in non-suppurative infected hæmothoraces in which the temperature and infection appear to be settling with conservative treatment; several times fever has returned with too early rehabilitation in these cases. But with this exception, the sooner exercises begin the better. Special attention should be paid to the diaphragm, as this is frequently adherent; individual tuition in diaphragmatic respiration can here be of much value. There is a tendency, not confined to the laity, to regard a man who has had a hæmothorax as permanently unfit for full combatant service. This is partly due to the conception that all diseases of the lung are serious and a full recovery is unusual, partly to the idea that a chest wound is a 'Blighty' wound. With proper rehabilitation, which must include shoulder movements and general physical training, the majority of patients with uninfected hæmothoraces are soon fit for duty, first usually base duties, but many return to full combatant duties within three months.

MORTALITY

The mortality in the whole series of 1639 chest wounds at the Centre was 4·27 per cent.

SUMMARY

1. A series of 1639 penetrating chest wounds is analysed.

2. Secondary hæmorrhage in a hæmothorax is rare.

3. A clotted hæmothorax is often infected; evacuation of the clot and decortication is recommended.

4. The prevention of chronic empyema is discussed; decortication is of value in selected cases.

5. The indications for removing metallic fragments are outlined.

6. Fragments near the pericardium may cause recurrent attacks of pericarditis.

Acknowledgments.—This was the work of a Team. Lt.-Cols. J. G. Scadding and E. H. Rink, Majors O. H. J. M. Telling and J. C. Nicholson, Capts. R. W. Lush and C. R. Stevenson were all at some time my colleagues, and to them my thanks are chiefly due. In addition, it is a pleasure to thank the Consulting Surgeons, especially Major-General Ogilvie and Brigadier Edwards, for their help; Brigadier Boland and Colonel Churchill for their interest; Lt.-Col. Paul Wood, who has analysed the cardiac wounds with me; Major Cunningham for pathological studies; Major Maddocks for the radiographs; Capt. Brownell and Mr. Hennell for the reproductions; and Pte. Coupland for much clerical assistance.

Finally, acknowledgments are due to the various Officers Commanding Hospitals in which the team has worked, particularly Col. W. J. F. Craig, O.B.E., Officer Commanding the Hospital in which the majority of the work has been done.

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SURVEY OF ABDOMINAL WOUNDS IN 21 ARMY GROUP (JUNE, 1944—MAY, 1945)

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The abdominal wounds treated in 21 Army Group form the largest single group of cases operated upon in this war by British or Dominion surgeons, and the recovery-rate in the series has been relatively more favourable than usual. It is felt therefore that a statistical survey may help either to confirm or confound many impressions formed by those dealing with the cases.

The following table (*Table I*) gives the total figures from D-day to VE-day (June 6, 1944–May 8, 1945). These figures represent the work of over 100 British and Canadian forward surgeons, and of one attached Belgian Field Surgical Unit.

Table I.—Abdominal and Abdomino-thoracic Cases. Summary of Results D-day to VE-day

Type of Case	Cases	Deaths	Percentage Mortality
Penetrating or perforating abdominal wounds with intraperitoneal visceral injuries	3579	1065	30
Abdominal wounds with extraperitoneal visceral or vascular injuries, or intraperitoneal hæmorrhage with no discoverable visceral injury	740	73	10
Thoraco-abdominal or abdomino-thoracic wounds	786	333	42
Totals	5105	1471	29

Complete accuracy under the conditions prevailing during a war of rapid movement is obviously difficult to secure, yet every effort has been made to obtain the correct mortality-rates by cross-checking all death reports against the initial reports of the surgeons concerned, and it is believed that the figures are as nearly accurate as possible. The proximity of the United Kingdom, combined with the constant strain on hospital accommodation in B.L.A., meant that most abdominal cases were evacuated as soon as was reasonably safe—on an average about the eleventh or twelfth day—and it is therefore evident that the table does not provide the true final results. From the available incomplete information it would appear that the percentage of men with abdominal wounds who died after evacuation to U.K. was low.

An interesting pointer in this connexion is given in a recent report of 317 abdominal wounds by the Consulting Surgeon, N.Z.E.F. (Col. T. D. M. Stout, C.B.E.). In this series, treated and retained for considerable periods in C.M.F. during the Italian campaign, only 16 deaths occurred at Base Hospital level, and in the last eight months of the period under review none at all.

It should also be appreciated that the figures in the above table refer only to those abdominal cases that came within the scope of the forward surgeon, i.e., they exclude deaths occurring before a surgical level of evacuation was reached. Here again the N.Z. report merits comparison, where a very similar post-operative mortality of 27 per cent is correlated with an *overall* mortality-rate of 50 per cent.

SCOPE OF INVESTIGATION

In dealing with such large numbers as in *Table I* many analyses may be made provided sufficiently detailed records are available, but in the course of the campaign certain aspects became of more practical importance, and I have in the main concentrated upon these. Owing to information on essential points being incomplete, either relatively or in fact, many records were found to be unsuitable for detailed analysis for reasons given below.

Reports with adequate details for study of the points enumerated below involved analysing the records of :—

1038 men who had laparotomies for abdominal wounds (343 deaths).

912 men who died following laparotomy (including above 343).

208 men who were operated upon for thoraco-abdominal or abdomino-thoracic wounds.

The analysis, therefore, covers 1815 cases, and it is believed that these represent a fair sample of the entire total of 5105 cases.

Part I. Analysis of Laparotomies for Abdominal Wounds (1038 Cases)

A. Nature of the missiles producing the wounds.
B. Sites of entry.
C. Frequency of involvement of individual viscera.
D. Operative procedures used and their relative results.
E. Frequency, distribution, and effect of associated wounds.
F. Incidence of complications.
G. Mortality-rate :—
  1. Overall mortality.
  2. Mortality related to groups of viscera involved.
  3. Mortality related to individual viscera involved.
H. Analysis of results related to status of patients.

Part II. Analysis of Fatal Cases following Laparotomy (912 Cases)

A. Time of death after operation.
B. Causes of death.
C. Correlation of the two preceding analyses.
D. Analysis of deaths due to peritonitis :—
  1. Wound/operation interval.
  2. Incidence and degree of peritoneal soiling.

PART III. THORACO-ABDOMINAL AND ABDOMINO-THORACIC WOUNDS (208 CASES)

A. Frequency of involvement of individual viscera.
B. Surgical approach employed.
C. Mortality-rate :—
1. Overall mortality.
2. Mortality related to visceral involvement.

SOURCES OF INFORMATION

The information has been extracted from the monthly reports submitted by surgeons of field surgical units, casualty clearing stations, and forward (200 beds) hospitals, and from the reports on deaths rendered by all units. It was a rule that *all* deaths had to be reported, but the official *pro forma* merely requested that all interesting cases, including abdominal and thoraco-abdominal cases should be recorded. As a result the information about the fatal cases was relatively more complete, and if a survey were made by extracting all cases *with sufficiently complete details* from all available reports a false picture would be obtained since a disproportionate number of deaths would be included.

Considering the stress under which surgeons often worked, the quality of most reports was very good, but naturally individuals had their own ideas about the relative importance of various factors and findings, with consequent variation in records. Nearly all surgeons supplied complete details about their more serious and spectacular cases, the ones naturally carrying the greatest risk, and either they or their parent unit supplied reports on all fatal cases. On the other hand, many reported their successes very briefly, e.g., " Gnr. Smith, J., R.A., S.W. Pent. Abdo. Three holes in ileum sutured. Uneventful recovery, Evacuated ". For this type of investigation such records, lacking in certain essential details such as site of entry, wound/operation interval, operation/evacuation interval, etc., are insufficient.

The problem arose, therefore, of securing a representative sample of the whole series, and has been answered by using only those reports containing adequate records of *all* cases. Reports in which the less serious cases were recorded briefly and only the more serious or fatal cases in detail were rejected. This has been considered essential if a balanced picture is to be obtained, although such strict selection has meant the elimination of some large groups with much more favourable recovery-rates than the average, e.g., one series of about 200 cases with a mortality-rate of approximately 20 per cent.*

A leavening of the more experienced field surgeons was always introduced at strategic forward points, and these men operated upon a relatively greater number of cases. Their skill and experience produced excellent results and saved many desperate cases, yet these men were often so busy that they had least time to prepare the detailed reports required to provide the best material for a statistical analysis. The non-utilization, for the reasons stated, of a number of such reports explains the somewhat higher mortality-rate in the sample than in the gross total. The figures in the analysis represent an over-estimate rather than an under-estimate of the mortality—admittedly a fault, but one in the right direction.

* I understand that an analysis of this very fine series is to be published elsewhere by the surgeon concerned—Major B. Eaton, R.C.A.M.C.

PART I. ANALYSIS OF 1038 LAPAROTOMIES FOR ABDOMINAL WOUNDS

A. **Analysis of Nature of Missiles** (*Table II*).—There were 361 cases in which the nature of the missile was unknown or was not stated. Many men cannot say what weapon produced their wounds, and even when the foreign body is discovered it is not always possible to determine its origin.

Table II

MISSILE	TOTAL	PERCENTAGE
Shell	288	43·0
S.A.A.	278	41·5
Mortar	30	4·0
Mine	24	3·5
Bomb	22	3·0
Vehicle	15	2·0
Grenade	13	2·0
Crush	4	·6
Bayonet	2	·3
Blast	1	·1
Totals	677	100·0

Owing to some looseness in terminology the above figures are possibly rather inaccurate. There was a tendency to record wounds as due to G.S.W. when the missile was not small-arms ammunition; this gives a higher figure to that group than was probably the case. Mortar injuries were almost certainly more common than 4 per cent, but were often recorded as shell wounds.

B. **Analysis of Sites of Entry Wounds** (*Table III*).—There were 238 cases in which the exact site of entry wound was not stated. Cases under the heading ' Chest ' are those in which the entry wound was above the costal margin but did not involve the diaphragm; cases under the heading ' Nil ' were injuries due to blast, falling masonry, vehicle accidents, etc.

Table III

SITE	TOTAL	PERCENTAGE
Anterior abdominal wall	330	41·250
Buttock	151	18·875
Right flank	87	10·875
Left flank	83	10·375
Posterior abdominal wall	53	6·625
Thigh	36	4·500
Chest	30	3·750
Nil	30	3·750
Totals	800	100·000

The relatively high proportion of entry wounds in the thigh is noteworthy, as is also the fact that the buttock was second only to the anterior abdominal wall as the commonest site of entry.

C. **Frequency of Involvement of Individual Viscera** (*Table IV*).—In 1038 laparotomies lesions

were found of 1544 individual viscera. Multiple lesions of individual viscera have been counted as one lesion. In 24 cases no intraperitoneal lesion was discovered, although in some of these there was intraperitoneal hæmorrhage. The relative frequency is expressed as a percentage of the total lesions. (*Fig.* 313 also sets out the findings in pictorial form.)

Table IV

Organ	Lesions	Percentage of Total Lesions
Small intestine	484	31·34
Colon	380	24·61
Liver	157	10·16
Rectum	109	7·05
Miscellaneous	108	7·05
Stomach	107	6·93
Bladder	95	6·15
Kidney	58	3·75
Spleen	26	1·67
Pancreas	20	1·29
Totals	1544	100·00

The group under the heading 'Miscellaneous' includes lesions such as the mesentery, the omentum, and the retroperitoneal tissues—and one pregnant uterus !

It is interesting to note that the intestinal tract (from stomach to rectum) accounts for 70 per cent of the lesions. The stomach and the rectum appear to be equally vulnerable and the small intestine shows a significantly higher percentage of lesions than the colon.

D. **Analysis of Operative Procedures Used and their Relative Results** (*Table V*).—An attempt has been made to assess the results of different operative procedures. To get a true picture it has been necessary to discard all cases that had multiple abdominal lesions or which died from associated wounds.

Table V.

Organ	Operation	Total	Died	Percentage Mortality
Liver	Suture	14	3	21·4
	Packing	8	5	62·5
	Drain only, or nothing	36	5	13·9
Spleen	Splenectomy	8	1	12·5
Kidney	Nephrectomy	17	6	35·3
Bladder	Suture	4	1	25·0
	Suture and suprapubic	23	4	17·4
Stomach	Suture	19	4	21·0
Small intestine	Suture	139	22	15·8
	Resection	54	20	37·0
Colon	Suture	13	3	23·1
	Exteriorization	95	27	28·4
Rectum	Colostomy	30	9	30·0

The majority of liver injuries required neither suture nor packing. When either of these was necessary the mortality rose, the increase being much greater in the case of packing. The high mortality in kidney wounds of battle origin should be noted and is again evident in *Table XI*.

As expected, the majority of small-intestinal lesions were treated by suture. When resection was necessary the mortality was over twice as great. The apparent relative success of suture of the colon can

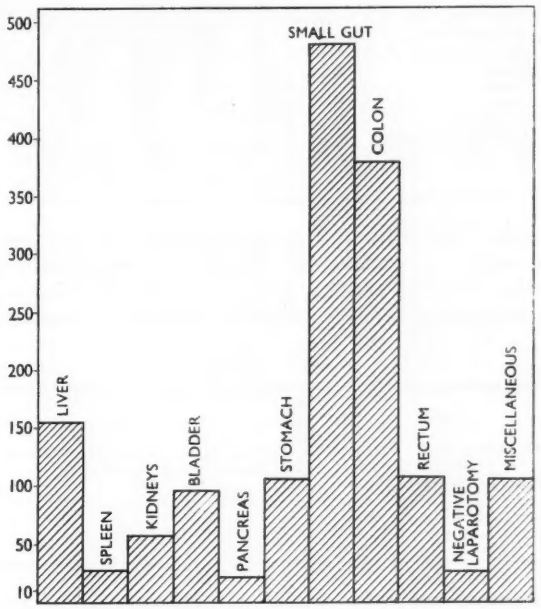

Fig. 313.—The frequency of involvement of individual viscera (1038 cases; 1544 lesions).

be to some extent accounted for by the fact that only in minor wounds of the large intestine was it likely that this procedure would be carried out. The well-recorded, but often forgotten, mortality associated with a colostomy is borne out by the above figures.

E. **Frequency, Distribution, and Effect of Associated Wounds** (*Table VI*).—In the 1038 patients there were 207 men with other wounds of sufficient gravity to be recorded (20 per cent). For the purpose of analysis these are recorded under three headings :—

Class I.—Minor Wounds. These include soft-tissue wounds, the less serious open fractures, and superficial wounds of the head and chest. There were 62 such cases. (Trivial wounds are not recorded.)

Class II.—Severe Wounds. These include penetrating wounds of the head and chest, more serious open fractures, amputations, and spinal injuries. There were 123 such cases.

Class III.—Severe Wounds Directly Responsible for Death. The only cases placed in this category are those in which the evidence suggested that the associated wounds played an overwhelming part in the death of the patient. There were 22 such cases.

Effect of Associated Wounds on Mortality-rate.—As stated above, in 22 cases (2·13 per cent of the total) the cause of death was due to the severity of the associated wounds rather than to the abdominal

Table VI.—Distribution of Associated Wounds

Site of Wound(s)	Number of Cases	Percentage
Open fractures and traumatic amputations	88	42·51
Flesh wounds of limbs	60	28·99
Spine	22	10·62
Chest	18	8·70
Head	15	7·25
Trunk	3	1·45
Multiple wounds	1	·48
Totals	207	100·00

wound. An estimation of the effect on the mortality-rate when an abdominal wound is complicated by another wound can be gained by determining the mortality-rate for abdominal wounds alone and abdominal wounds associated with other wounds (*Table VII*).

Table VII

Class	Total	Recovered	Died	Percentage Mortality
Abdominal wounds alone	831	583	248	29·84
Abdominal wounds with other wounds	207	112	95	45·89

In this series there was a 16 per cent increase in the mortality-rate when an abdominal wound was associated with another serious wound.

F. **The Incidence of Complications** (*Table VIII*).—I believe the number of complications recorded is lower than actually occurred. Many surgeons did not mention them unless they gravely affected the course of the patient's post-operative history. This is well shown by the number of cases of jaundice reported. Transient jaundice was a very common complication; every one of the small number of cases recorded below was of sufficient gravity to prejudice the chances of recovery.

Table VIII

Complication	Number
Abdominal wall:—	
Burst incision	11
Severe infection	15
Peritoneal infection :—	
Pelvic abscess	3
Subphrenic abscess	1
Intestinal obstruction :—	
Dynamic	16
Organic	6
Respiratory :—	
Bronchopneumonia	19
Massive collapse	3
Pulmonary embolus	7
Miscellaneous :—	
Uræmia or anuria	14
Jaundice	13
Mental changes	12
Fæcal fistula	7
Pancreatitis	1
Mesenteric thrombosis	1

Even in this necessarily incomplete series, the relative frequency of anuria and jaundice is worthy of note.

G. **Mortality-rate.—**

1. *Overall Mortality* (*Table IX*).—When estimating the overall mortality-rate in this series every patient who died in forward areas after a laparotomy or an attempted laparotomy has been included. The figure includes men who died from other wounds and those who died during the induction of anæsthesia prior to operation.

Table IX

Total Number of Laparotomies	Deaths	Percentage Mortality
1038	343	33·04

2. *Mortality Related to Groups of Viscera Involved* (*Table X*).—The cases have been divided into four main groups according to the viscera damaged: wounds of the alimentary tract; wounds of the solid viscera (including the bladder); combinations of these two groups; and wounds of the supporting structures and tissues (including mesentery, omentum, peritoneum only, and retroperitoneal tissues).

Table X shows that injuries of the solid viscera are less lethal than wounds of the alimentary tract, and that when the two are combined the mortality-rate rises steeply. The death-rate in men with lesions of the supporting structures and in those where no visceral injury was discovered is perhaps surprisingly high. This is partly due to the presence of other serious wounds in several of the cases concerned. The figures confirm the impression that a laparotomy on any wounded man involves a serious risk to life.

Table X.

Group	Total	Recovered	Died	Percentage Mortality
Alimentary tract	594	398	196	32·99
Solid viscera	135	100	35	25·92
Combinations of above	177	87	90	50·84
Supporting structures	108	90	18	16·67
Negative laparotomies	24	20	4	16·67

3. *Mortality Related to Individual Viscera Involved* (*Table XI*).—This table provides a comparison between the mortality-rate when only one viscus is involved and when it is injured in combination with others. (Also shown in *Fig.* 314.)

Several groups in this table are so small that the possible range of statistical error is great. It reveals once again the much greater risk associated with multiple lesions. The mortality-rate in men with genito-urinary injuries is higher than most imagine, while the figures do *not* confirm the common belief that wounds of the colon are far more dangerous

Table XI

Organ	Number of Cases		Percentage Mortality	
	Alone	Combined	Alone	Combined
Small intestine	203	281	24	48
Colon	177	263	11	69
Liver	58	99	24	48
Rectum	39	70	36	50
Bladder	28	67	21	45
Stomach	20	87	25	51
Kidney	17	41	35	56
Spleen	9	17	11	69
Pancreas	1	19	—	42

than wounds of the stomach and small intestine. Rectal wounds, however, both alone and in combination maintain their sinister reputation.

H. **Analysis of Results Related to Status of Patients** (*Table XII*).—The cases have been divided into officers, other ranks, prisoners of war, civilians, and unknowns.

Table XII

Group	Total	Percentage of All Cases	Percentage Mortality-rate
Officers	55	5	36
Other ranks	742	72	33
Prisoners	167	16	35
Civilians	37	3·5	49
Unknowns	37	3·5	11

It will be seen that *qua* fatal abdominal wounds, officer and man appear to be exposed to almost equal risk. The mortality amongst prisoners is unexpectedly low. Owing to difficulties of collection and evacuation from the battlefield and the tendency to operate on Allied personnel first, there was naturally a greater delay before a prisoner reached operation. It was expected that there would be a corresponding increase in the mortality-rate, but this expectation is not confirmed. The probable explanation may be the 'natural selection' that occurs when there is a delay in operation—only the less serious cases surviving long enough to reach the surgeon. The high mortality-rate among civilians may be due to two factors: their poor general condition due to inanition, and the undue proportion of old people and infants in this group.

The low mortality among the group of 'unknowns' is due to the fact that only four death reports in this series did not give the rank of the patient.

PART II. ANALYSIS OF 912 FATAL CASES FOLLOWING LAPAROTOMY

In order to get a larger sample of deaths, a further 569 cases with detailed records were selected and added to the 343 already available from the first analysis of 1038 laparotomies. This provided a total of 912 cases.

A. **Analysis of Time of Death after Operation** (*Table XIII*).—This table confirms the findings in previous reports which have stressed the point that the majority of deaths occur in the first two or three days after operation.

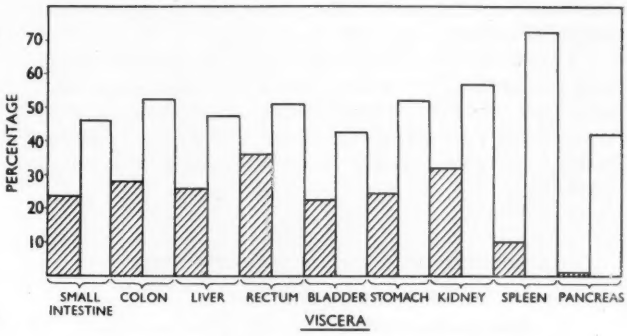

Fig. 314.—Mortality in wounds of individual viscera (alone and combined).

Almost two-thirds of the deaths in this series (64 per cent) occurred during the first 48 hours and 48 per cent were within 24 hours. Only 10 per cent of the deaths took place after the first seven days. In this respect a comparison with the figures of the N.Z. series is of interest. Corresponding figures are 70 per cent in 48 hours and 50 per cent in 24 hours.

Table XIII

Interval	Number	Percentage of Total
Death in theatre	55	6·0
1st day	385	42·2
2nd day	148	16·2
3rd day	83	9·1
4th day	41	4·5
5th day	51	5·6
6th day	25	2·7
7th day	32	3·5
8th day	11	1·2
9th day	10	1·1
10th day	13	1·3
11th day	7	0·8
12th day	6	0·7
13th day	7	0·8
14th day	6	0·7
15th day	5	0·6
16th day	2	0·3
20th day	2	0·3
28th day	1	0·2
Not stated	22	2·3

B. **The Causes of Death** (*Table XIV*).—The term 'Shock' has been used to describe the cause of death in those severe cases that never picked up after operation. This group, two cases in every five, consists of those cases the gravity and extent of whose injuries made them really hopeless from the start. They simply serve as an indication of the forward surgeon's willingness to tackle even the most forlorn chance.

Those under the heading 'Respiratory Obstruction' died as the result of inhaling vomit during or after operation. The figure of 1·2 per cent is disquieting, but patients often reach the surgeon with their stomachs full of glutinous stew and the anoxæmia that results while this clinging mass is sucked from the air-passages may be sufficient to tip the scales in a gravely shocked patient with a precariously balanced cardiovascular system. That death should have occurred so often from this cause suggests that time would be well spent in employing some prophylactic measures against vomiting, and emphasizes

the value of adequate pre- and post-operative treatment in preventing such calamities.

Many of the cases of peritonitis or retroperitoneal and pelvic cellulitis were established before operation was possible. As subsequently shown the average wound/operation interval in all cases was 12 hours, but in the cases dying from peritonitis it averaged 21 hours.

Table XIV

Cause	Number	Percentage of Total
'Shock'	358	39·4
Peritonitis	102	11·1
Associated injuries	43	4·7
Renal failure	30	3·3
Intestinal obstruction :		
a. Dynamic 13		
b. Organic 6	30	3·3
c. Unstated 11		
Pneumonia	28	3·1
Hæmorrhage	22	2·4
'Heart failure'	22	2·4
Sepsis (extraperitoneal)	18	2·0
Pulmonary embolus	15	1·6
Respiratory obstruction	11	1·2
Liver damage	5	·5
Mental changes	5	·5
Unknown	223	24·5

was carried out to show the interval after operation at which the various causes were predominant.

The table sets out the findings in detail and the graph (*Fig.* 315) shows the salient points more clearly.

The following points merit comment :—

1. '*Shock*' : The first 24 hours is the peak period for death from shock.

2. *Peritonitis* : Contrary to expectations the deaths from peritonitis reach their peak on the first to third days. They remain fairly steady, but at a much lower level, on the fourth to eighth days and thereafter only occur sporadically. This interesting result is partly explained by the fact that some of these cases undoubtedly reached the surgeon very late, with peritonitis already established before operation. A comparison of the wound/operation interval in all fatal cases and in those dying from peritonitis is given in the next section and the wound/death and operation/death intervals should not be confused.

This is not the whole story, however, and it seems probable that the almost universal use of penicillin in 21 Army Group as a routine part of the treatment of abdominal cases may have controlled or prevented many of the later septic complications.

Table XV

Cause of Death	Number of Deaths on Day after Operation																					
	0*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	28	Unknown
'Shock'	35	246	4	14	1	2																	6
Peritonitis	1	25	17	23	6	8	4	4	3		2	1				2	1				1	1	3
Associated wound(s)	3	15	11	3	3	2	1	1				1		1									1
Renal failure			3	4	8	8	1	3		1	1												1
Intestinal obstruction		1		1	3	9	5	4		1	1		1		1	2							1
Pneumonia			4	4	3	3	4	3	2	1	1	1	1			1							
Hæmorrhage	8	10									1			1									2
'Heart failure'	1	6	5	4	2	3								1									
Sepsis	2	2	2		1			3			1	1	2	1	2								1
Pulmonary embolus			1	3	3	2		1	2		2												1
Respiratory obstruction	1	6	2	1																			1
Liver damage			1		1				1			1											1
Mental changes		1		2		1				1													
Unknown cause	4	73	48	24	12	12	9	13	3	5	4	2	2	3	3		1				1		4

* 0 refers to the day on which operation was performed and the other figures on this horizontal line represent days after operation.

The number of lung infections was low, and it should be noted that in almost 5 per cent of deaths severe associated wounds were responsible rather than the abdominal wound itself.

Again, the relative importance of renal failure (anuria)—*see Table VIII*—as a cause of death is well shown by its place in the list.

C. **Correlation of the Time of Death and the Cause of Death** (*Table XV*).—This analysis These always account for a proportion of the deaths after the first few dangerous days when the mortality is greatest.

3. *Intestinal obstruction* : Deaths from this cause occurred most often between the fourth and seventh days. These were of the dynamic type. Sporadic deaths occurred up to the fifteenth day, and this latter group were due to organic obstruction.

4. *Renal failure*: 90 per cent of the deaths from renal failure occurred between the second and seventh days. The peak was on the fourth and fifth days.

5. *Cause unknown*: Everyone who has seen many abdominal cases due to wounds is only too familiar with those disappointing cases that die for no discoverable reason. In the words of the old song, "they simply fade away"—and in the majority a post-mortem examination provides no clue to the cause. Doubtless if full laboratory facilities were generally available in forward areas some visceral or biochemical upsets would be detectable, sufficiently adequate alone or in combination to sever the thin-spun thread of life.

6. *Associated wounds*: When these were sufficiently severe to be regarded as mainly responsible for the fatal issue, the death occurred most frequently during the first two days.

D. **Deaths due to Peritonitis.**—

1. *Wound/Operation Interval.*—The average interval from the time of wounding to operation in all cases in this series was 12 hours.

The average interval from the time of wounding to operation in all cases that died from peritonitis was 21 hours. As explained previously, in many of these the peritonitis was certainly established prior to operation.

It should be emphasized that the above figure means that nearly a day has to be added to the time of death after operation to get the true figure for death from peritonitis after wounding. This partially explains the somewhat unexpected finding (*see Table XV* and *Fig.* 314) that peritonitis was responsible for approximately 7 per cent of the deaths during the early days of convalescence.

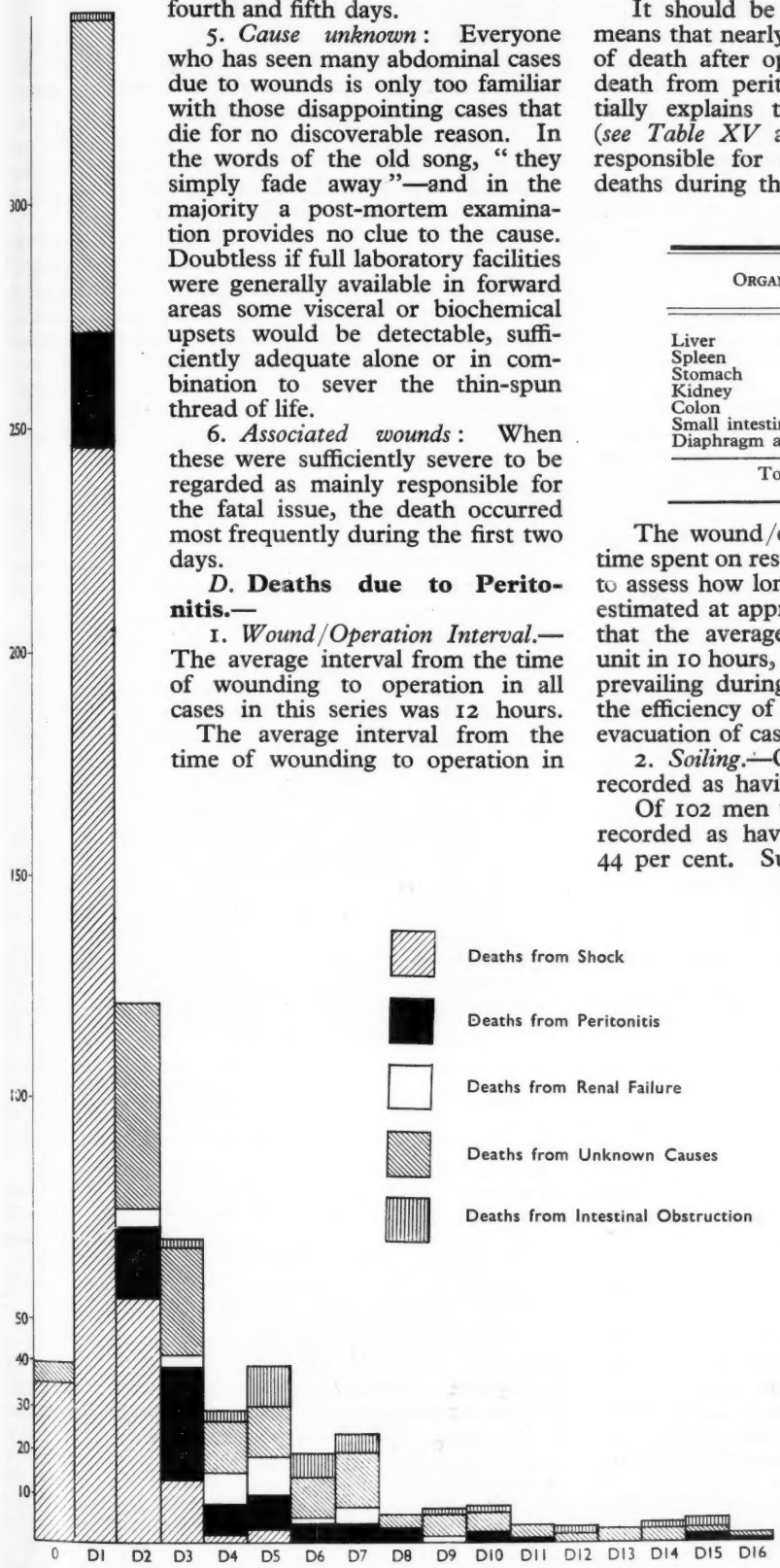

FIG. 315.—Major causes of death in relation to time of death.

Table XVI

ORGAN	NUMBER OF LESIONS	PERCENTAGE
Liver	106	33
Spleen	64	20
Stomach	51	16
Kidney	40	12
Colon	31	10
Small intestine	17	5
Diaphragm alone	13	4
Totals	322	100

The wound/operation interval also includes the time spent on resuscitation. It has not been possible to assess how long this was on the average, but it is estimated at approximately two hours. This means that the average case reaches a forward surgical unit in 10 hours, and under the conditions frequently prevailing during a battle this is fine testimony to the efficiency of all concerned in the collection and evacuation of casualties from the field.

2. *Soiling.*—Of 912 men who died, 121 were recorded as having significant soiling—13 per cent.

Of 102 men who died from peritonitis, 44 were recorded as having significant peritoneal soiling—44 per cent. Such figures require no comment.

PART III. INVESTIGATION OF 208 CASES OF THORACO-ABDOMINAL AND ABDOMINO-THORACIC WOUNDS

The records of 208 cases of thoraco-abdominal and abdomino-thoracic wounds have been investigated and the following information extracted:—

A. **Frequency of Involvement of Individual Viscera** (*Table XVI*).—In the 208 cases 321 viscera were found to be involved.

In this table naturally every grade of visceral injury is represented—from the trivial to the catastrophic. In all true thoraco-abdominal and abdomino-thoracic wounds the diaphragm is perforated and that was so in this series, but in a small number no associated visceral lesion was discovered. There may have been minor liver or lung damage, but the wise surgeon does not explore officiously

when there is obviously no major lesion requiring surgical attention.

B. **The Surgical Approach Employed.**—Varying opinions have been expressed as to the relative merits of an abdominal or a thoracic approach in thoraco-abdominal wounds. An investigation was made to discover which was used more frequently. Thoracic incisions varied from orthodox intercostal incisions to wound extensions. The abdominal incisions employed were usually paramedian, rectus splitting, or occasionally oblique. It was not possible to differentiate in more detail the incisions used.

The necessary information was available in 124 cases :—

	Cases	*Per Cent*
Abdominal approach	75	61
Thoracic approach	49	39

The mortality-rate was determined for each group, but the figure is not of great value as there were so many variables. Many of the thoracic approaches were simply explorations of wounds of the liver through the original wound.

	Per Cent
Mortality-rate for wounds explored through abdominal incisions	40
Mortality-rate for wounds explored through thoracic incisions	26

Many surgeons comment in their reports upon the fact that if the abdominal lesions are confined to the left upper quadrant a thoracic approach provides an excellent exposure, and that procedures such as splenectomy can be performed with ease by this route.

C. **The Mortality-rate** (*Table XVII*).—

1. Of the 208 patients in this series 80 died, a mortality-rate of 38 per cent.

2. Mortality related to visceral involvement.

Table XVII

Organ	Wounded Alone		Wounded in Combination		Percentage Mortality	
	Number	Died	Number	Died	Alone	Combined
Liver	55	8	51	29	15	57
Spleen	25	8	39	18	32	46
Stomach	7	3	44	30	43	68
Kidney	5	1	35	18	20	51
Colon	5	1	26	16	20	63
Small intestine	5	2	12	10	40	84
Diaphragm alone	13	5	—	—	26	—

The outstanding point brought out by this table is the high mortality associated with all wounds of the alimentary tract, whether injured alone or in combination. The fact that cases recorded under 'Diaphragm Alone' produced a mortality of 26 per cent and 'Liver Alone' one of 15 per cent, suggests that the injuries in the former group were more extensive than was detected at operation. It should be added that if a post-mortem was performed and a 'missed' lesion found, most surgeons were sufficiently honest to record this in their reports.

SUMMARY

Of the 5105 abdominal wounds reported during the 1944–45 North-Western European campaign a series of 1815 has been selected as a suitable sample of the whole for statistical analysis.

This analysis has been divided into three parts :—

1. 1038 laparotomies for abdominal wounds.
2. 912 fatal cases following laparotomy.
3. 208 thoraco-abdominal wounds.

The findings have as far as possible been recorded in tabular form. The following findings of interest are amongst those that emerge from the analysis :—

1. An overall mortality of 29 per cent is reported in 5105 cases of abdominal and thoraco-abdominal wounds.
2. The intestinal tract (stomach to rectum) accounts for 70 per cent of the wounds.
3. The small intestine is injured more frequently than the colon ; the mortality in both groups is very similar.
4. Injuries of the solid viscera are less lethal than those of the intestinal tract.
5. The association of another serious wound with the abdominal wound raises the mortality-rate 16 per cent.
6. Officer and man seem equally liable to death from abdominal wounds.
7. The buttock is second only to the anterior abdominal wall as the commonest site of entry.
8. Jaundice and anuria were amongst the commonest post-operative complications.
9. 1·25 per cent of deaths were due to preventible respiratory obstruction.
10. 64·4 per cent of all deaths occurred in the first 48 hours after wounding ; 48 per cent in the first 24 hours.
11. Average wound/operation interval was 12 hours ; in deaths from peritonitis 21 hours, these latter being most frequent from the first to the third day post-operatively.
12. The highest mortality in the thoraco-abdominal cases occurs in the group in which the abdominal part of the injury involves the alimentary tract.

My grateful thanks are due to the D.M.S., 21 Army Group (Major-General E. Phillips, C.B., C.B.E., D.S.O.) for permission to publish this paper ; to Lt.-Col. B. McN. Truscott, who, with the staff of his Field Surgical Unit, was entirely responsible for the production of all the figures used in this report ; to Lt.-Col. G. A. G. Mitchell for invaluable help in deciding the scope of the investigation and the form of its presentation ; and to all the Forward Surgeons of 21 Army Group whose excellent reports have made that presentation possible.

SPONTANEOUS GANGRENE OF THE SCROTUM (FOURNIER'S GANGRENE)

By O. T. MANSFIELD

The occurrence of complete and apparently causeless gangrene of the scrotum in an otherwise healthy patient is an unusual condition and of sufficient interest to warrant a report of the following case.

CASE REPORT

A man of 43 was admitted to an E.M.S. hospital moribund. No accurate history was available at the time, but his wife has since been able to penetrate the fog of toxic amnesia with a few details of the onset and course of the disease. Five days before admission the patient first noticed "pain and swelling in the lower parts"; until that time he had been well except for a heavy cold, which was still upon him. The swelling continued, and on the next day delirium first appeared; from this time amnesia was complete. On the third day his wife noticed that the inflamed parts had turned very white. Toxæmia was considerable at this time and increased with the progressive change of the inflamed area to a white colour.

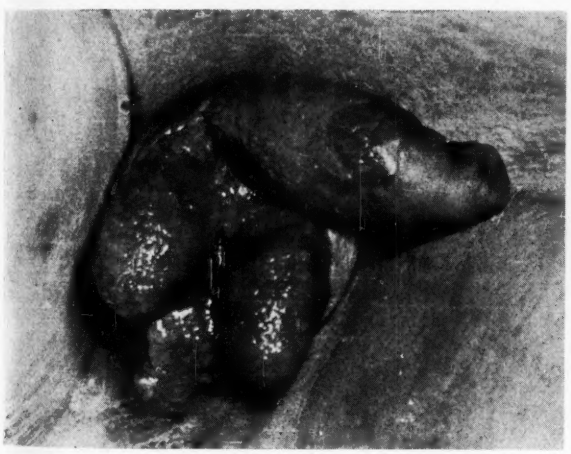

Fig. 316.—Condition on admission to plastic unit about ten days after operation, marginal sloughs having separated. Area of skin loss which is just visible at the base of the penis extends along the whole of the under surface.

On Examination.—The patient was extremely ill, cerebration was sluggish and answers to questions could only be obtained after repetition. There was gross dehydration with a dusky, yellow coloration of the skin. Examination locally showed, between his thighs, a cold flaccid mass about the size of a coco-nut. This was an entirely gangrenous scrotum, from which a horrible smell arose; the penis was extremely œdematous, and there was spreading cellulitis from the pubic region to the costal margin on both sides and extending outwards into the loin. This was most marked in the iliac fossa and faded out as the costal margin was reached. Enlarged inguinal glands were present, but without evidence of cellulitis. The patient was too ill to warrant any active interference, but after the administration of intravenous glucose-saline his general condition was sufficiently improved to justify surgical intervention.

At Operation.—Examination in the lithotomy position showed that the whole of the scrotum, with the exception of three small triangular areas, was entirely gangrenous. This gangrene extended along the under-surface of the penis for the full length and for a width of about 1½ in. of the circumference of the œdematous part. Incision into the area produced a free flow of turbid fluid, culture of which gave a heavy growth of hæmolytic streptococci +++ and *Staph. aureus* ++.

The scrotum was then split into halves by division in the plane of the septum, and before the urethra was reached bleeding vessels were found. Dissection was continued laterally on either side until the whole of the gangrenous area was removed, together with the affected under-surface of the penis. This gave a most remarkable appearance. All that remained of the scrotum was three triangular flaps about 1½ in. in length and of equal width at the base. Two of these were based laterally and one posteriorly. Between them lay both testes completely exposed, the parietal layer of the tunica vaginalis having been removed. These and all the structures of the spermatic cords were entirely normal, the former being covered with an unaffected serous layer. Anteriorly the cords disappeared beneath the overhanging edge of pubic skin. Section of the area removed showed no abnormality other than marked interstitial œdema with many thrombosed vessels. Investigation of the urinary tract was not carried out at operation as it was felt that this might precipitate a renal infection. Before operation the patient had passed a few ounces of clinically normal urine without difficulty.

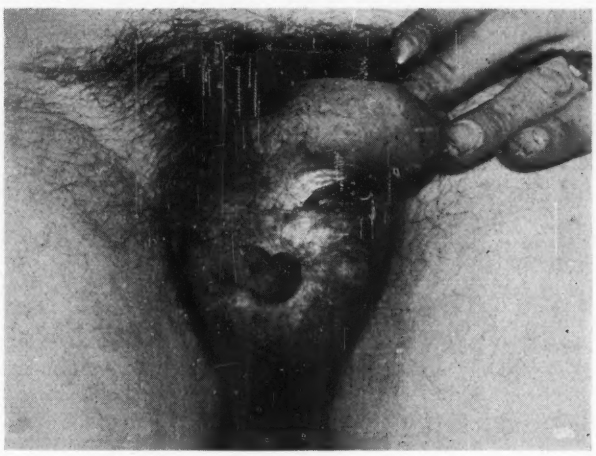

Fig. 317.—Condition one year after discharge from hospital. Both testes are freely mobile in the scrotum. There is a scar band between the under surface of the penis and the anterior surface of the scrotum, but this produces negligible disability.

Progress.—Five days after operation the general condition was sufficiently improved for him to be transferred to an E.M.S. plastic unit for convenience of dressings in the saline bath and for consideration of plastic repair of the area excised. By this time the cellulitis of the abdominal wall had completely subsided, and apart from a small margin of slough around the skin edges the wound was clean. (*Fig.* 316.) About a week later he was out of bed. Separation of the remaining sloughs and epithelialization occurred rapidly. Six weeks after operation the patient was discharged soundly healed.

He attended for review some two months later, when there were no urinary symptoms; a 14/16 bougie was passed without difficulty and there was a well-formed but small scrotum in which the testes were freely mobile. Further surgery to free the posterior part of the penis from the anterior scrotal wall was refused by the patient. *Fig.* 317 shows the condition one year after discharge.

DISCUSSION

Spontaneous gangrene was originally reported by Fournier in 1884, when three salient features of the condition were described. These were: (1) The explosive onset in an otherwise healthy man; (2) The rapid progress of the gangrene; and (3) The total absence of the usual causes of gangrene. Since then cases have been reported from time to time in the literature which have more or less fulfilled these criteria, but a study of these reports shows other factors which are common in a majority of cases. These are:—

1. Extensive and fairly constant area of gangrene. While cases of partial loss have been reported, in many of the published series gangrene was of the pattern described above and involved a similar area. Although no description of the three flaps observed by us has been encountered, the photograph of a case reported by Brown and Smith (1939) shows a very close correspondence with *Fig.* 316. The integrity of the testes and the inguinal and anal regions appears to be constant. It has been noted specifically in previous reports that although sloughing of the anterior abdominal wall has been recorded, reports of involvement of areas other than the penis and scrotum are extremely rare.

2. Rapid resolution of the adjoining cellulitis, together with a corresponding improvement in the patient's general condition when the sloughing area has separated.

3. A tendency for spontaneous repair to occur. This is very striking and has been noted with particular emphasis by earlier authors. We believe that this tendency strongly supports our contention that the three flaps described are present in all cases. The diagram (*Fig.* 318) illustrates how difficult spontaneous closure would be if the loss extended to the sulcus between the perineum and the medial surface of the thigh, quite apart from the disability which would arise if a mass of scar tissue united the thighs in the coronal plane and the penis to the anus in the sagittal plane.

In two cases reported recently surgical repair has been attempted; in one by direct suture and undermining four days after the slough had separated, in which case obviously no time had been given for spontaneous closure. In the other, bilateral thigh flaps were used; again, soon after the separation of the sloughs.

Aetiology.—Two theories are held as to the origin of this condition. The one favoured by most French authors is that it is a fulminating erysipelas. This does not explain why such a disastrous form of the disease should occur in this region, neither does it take into account those cases in which the infection is not due to hæmolytic streptococci. It is also noteworthy that this condition is not seen commonly in fever hospitals nor in association with burns. In fact, it was emphasized in the original description that it arises spontaneously in otherwise healthy persons.

Gibson (1930) considers that the disease is in fact a gas gangrene due either to *B. Welchii* or to other anaerobes, in which sufficient search has not been made for the causative organisms. In support of this he claims, first, that "the rapidity with which the gangrene develops and the profound toxæmia which accompanies it have no parallel in gangrenous processes of known cause, with one exception, and that is gas gangrene", and secondly, that "streptococci usually occur in symbiosis with the gas-producing anaerobes, and, in fact, may obscure the true nature of the condition by their overwhelming numbers".

We are unable to accept the first statement; it must be generally accepted that the form of gangrene most rapid in its onset and development is one in

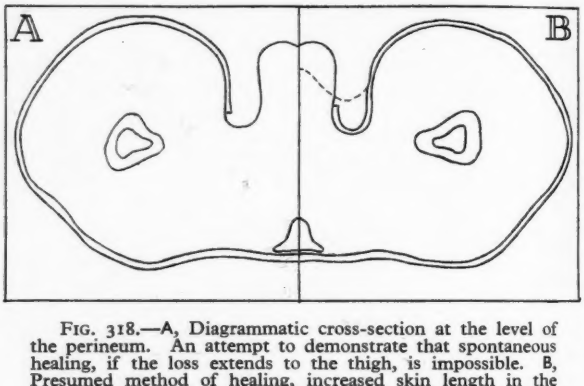

FIG. 318.—A, Diagrammatic cross-section at the level of the perineum. An attempt to demonstrate that spontaneous healing, if the loss extends to the thigh, is impossible. B, Presumed method of healing, increased skin length in the transverse plane being obtained by stretching of the small scrotal flap together with lowering of the vertical depth of the sulcus between the thigh and the scrotum.

which vascular occlusion has suddenly developed. The second claim we admit as an isolated statement, but cannot consider it as a point of great value in determining the aetiology of the condition under discussion. Neither of these explanations explains how the infection arises, nor why adjoining areas, such as the anal, inguinal, or testicular regions, should survive unscathed amid such destruction. Nor do they account for the existence of the three flaps described in this case and which we believe to be usually present.

An alternative explanation is that the condition is a vascular disaster of infective origin, analogous to cavernous sinus thrombosis. The infection is not believed to have any specificity other than the existence of a pathogenic organism which causes rapid thrombosis in the vessels of the septum of the scrotum with consequent necrosis of the area supplied by these vessels. The extreme rarity of the condition strengthens the analogy to cavernous sinus thrombosis, for this latter, despite the existence of millions of infected lesions of the face in the world at any one time, remains a relatively uncommon condition.

The fairly constant pattern of the area sloughed is again adequately explained on a vascular basis, and only this pathology can account for the existence of the flaps described. These are supplied by the external pudendal branch of the femoral artery and the superficial perineal arteries. The localized skin

loss on the under surface of the penis is also to be expected as the dorsal vein remains intact, having no connexion with the veins of the mediastinum below the urogenital diaphragm.

The onset of the gangrene in published cases has been from 12 hours to 15 days, with a maximum occurring at 3 days in 10 out of 40 cases reported by Gibson. This rapid gangrene is comparable to that occurring in a flap of skin and subcutaneous tissue which has become infected and its limited vascular supply destroyed by thrombosis. Gangrene in these cases occurs with extreme rapidity and the loss may be complete in a few hours. Under these circumstances the testes can be expected to escape.

Surgical Treatment.—

1. Allen, reporting cases in 1894, recommended complete castration. This is, of course, quite unnecessary.

2. Since then the usual treatment appears to have been multiple incisions until the slough has separated, with the adjuvant use of anti-gas-gangrene serum, zinc peroxide, etc., according to the views held as to the aetiology.

3. On the basis of the theory postulated in this paper, radical removal of all sloughing areas is advocated not only to save time but to rid the patient of an area which is irretrievably lost. Excision also provides the freest possible drainage. Sulphonamides or penicillin would be useful adjuvants after the bacteriology had been determined. Repair would usually seem to be unnecessary.

Mortality.—This in published cases varied between 22 per cent in 36 cases (Whiting, 1905) and in 145 cases (Coenen and Przedborski, 1911), to 31 per cent in 16 examples of this condition out of 147 cases of gangrene of the scrotum in the Philadelphia Hospital reported by Randall (1920). Death in most instances has been due to toxæmia. In a few, metatastic phenomena have developed.

Bacteriology.—Gibson has collected 206 cases from the published reports, and these he divides into two categories: (1) Those with some coincident or antecedent lesion; and (2) Those in which no lesion can be discovered.

In the first category are cases which cannot be considered as Fournier's gangrene. These include cases of inguinal adenitis, wounds, and obstruction. Of the second group, in 98 no cause was given as being responsible for the condition and 23 had minor conditions present, of which 11 had given rise to pruritus locally. Of those in group (2), 15 were due to hæmolytic streptococci, 3 to staphylococci, 6 to mixed streptococci and staphylococci, and 1 each to *B. coli*, *B. fusiformis*, and *B. Welchii*; 5 were infected by bacteria called by a nomenclature which is not standard.

It will thus be seen that the overwhelming number of cases in which the bacteriology has been determined are due either to streptococci or staphylococci or to the two together.

Literature.—This has been well summarized by Randal (1920), Gibson (1930), and Browne and Smith (1939). The first two of these authors give a very full bibliography. Since then cases have been reported by Carver (1939), Howard (1940), Lamierre (1940), and Hunter (1930). Some of these papers are not at the moment obtainable.

My thanks are due to Rainsford Mowlem, Surgeon-in-Charge, Plastic Unit, Hill End E.M.S. Hospital, for his help; to Dr. A. C. Cunliffe, of Sector 4, E.M.S. Pathological Laboratory, for bacteriological assistance; and to Miss D. E. Orpen for the diagram.

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A CASE OF HINDQUARTER AMPUTATION FOR CHONDROMYXOSARCOMA OF THE RIGHT THIGH

BY IAN M. HILL AND IAN P. TODD

THE first operation of this type is reported to have been performed by Billroth in 1889, but it was not until six years later that the first successful case (performed in two stages) was recorded by Girard (1895). Since then, about 110 cases have been described with an operation mortality in the region of 60 per cent (Gordon-Taylor and Wiles, 1935; King and Steelquist, 1943). The nomenclature concerning the operation is very varied; but the type performed in the case reported below is perhaps best described as a transilio-interpubic hindquarter amputation. This is the first operation of its kind to be reported at St. Bartholomew's Hospital, and the patient is, at present, well and free from complications.

CASE REPORT

HISTORY.—E. B., aged 49, a painter, entered Friern Emergency Hospital on June 21, 1944, complaining of pain down the right leg and a lump below the right groin, of six weeks' duration. The pain had increased in severity and was exaggerated by movement or by pressure over the mass. The pain radiated down the front of the thigh to just below the knee. There was no history of injury. Varicosities had appeared on the

medial side of the calf recently. He had lost 8 lb. in weight since the onset of symptoms.

EXAMINATION.—The right leg was held in 30° of flexion. Extension beyond this and flexion beyond 90° were painful. All rotatory movements produced pain. Muscle spasm at the hip was considerable.

In the upper thigh anteriorly and immediately below the inguinal ligament, there was palpable a smooth, hard, globular, sessile mass 2½ in. by 2½ in. feeling like bone, attached deeply, but not to the skin. The femoral artery could be felt running superficial to the mass, but displaced somewhat laterally. There was no impulse on coughing. The chest was clear and the blood-pressure 134/88 mm. Hg.

X-ray Report (June 23) (Dr. G. T. Loughborough).—"The lesser trochanter of the right femur shows a destruction of bone, combined with a certain amount of proliferation of fresh bone into the soft tissues of the

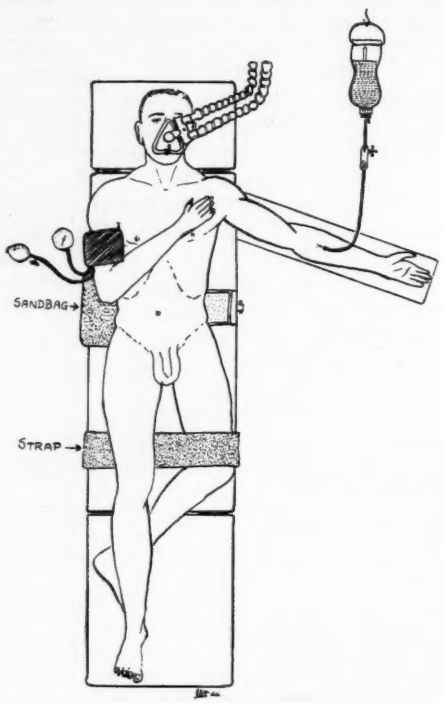

FIG. 319.—Position of patient on operating table.

thigh. This proliferation gives an irregular feathery appearance. The destructive process does not extend deeply into the shaft of the femur. There is slight bone reaction, limiting its spread inwards. Two areas of decalcification can be seen, one in the lower part of the neck of the femur and one in the ischium just below the acetabulum. These suggest secondary deposits. The chest is normal.

"Conclusion: There is an osteogenic sarcoma of the right lesser trochanter, with secondary deposits in the right femur and right ischium."

A biopsy was performed by Mr. J. B. Hume on June 26 through a 5-in. incision parallel to the medial border of sartorius and 2 in. below the anterior superior iliac spine. The lateral femoral circumflex vessels were divided and, presenting between the sartorius and rectus femoris, the tumour was found to arise from the femoral shaft close to the lesser trochanter. Macroscopically the tumour appeared to be a chondromyxosarcoma. This was confirmed by histological examination.

On July 7 the hæmoglobin was 94 per cent Haldane and blood group O (IV).

OPERATION.—On July 10 a hindquarter amputation was performed by Mr. J. B. Hume, of St. Bartholomew's Hospital. The anæsthetic (pentothal, cyclopropane, oxygen) was given by Dr. David Reckless.

The left medial antebrachial vein was exposed and a cannula for drip transfusion tied in place. The patient was placed on the operation table in the position indicated in *Fig.* 319.

The first portion of the incision was made over the inguinal ligament (*Fig.* 320), which was severed from its

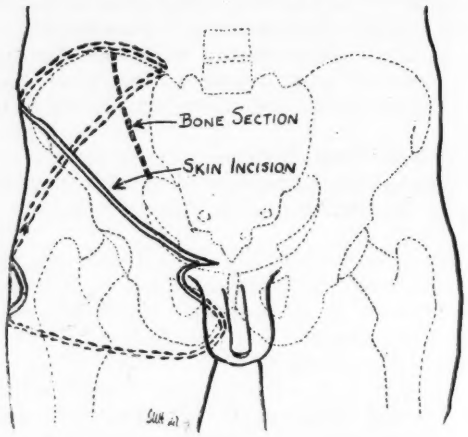

FIG. 320.—First portion of incision over the inguinal ligament.

bony attachments. The peritoneum of the right iliac fossa was stripped up and the external iliac vessels exposed and ligated (the vein after elevation of the limb) and the femoral nerve divided. The lateral extremity of the incision was extended along the iliac crest to the posterior superior iliac spine, and deepened until the oblique and transversus muscles were divided. The peritoneum

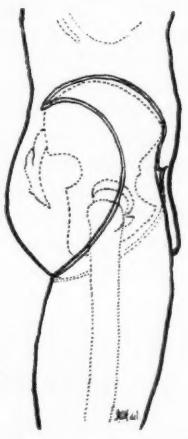

FIG. 321.—The completion of the incision.

was stripped up further, and a tape passed round the right common iliac artery. The rectus abdominis was detached from the pubic tubercle and symphysis and the retropubic space of Retzius opened. The limb was then widely abducted and flexed. The medial extremity of the first incision was extended along the conjoined ischiopubic ramus and the exposed bulb of the corpus cavernosum rugined from the bone. The bladder was then well retracted and the symphysis pubis divided with a knife. The limb was adducted and the incision carried from the ischial tuberosity to the greater trochanter and thence to the posterior extremity of the supracristal portion of the incision (*Fig.* 321). The

section of gluteus maximus lying posterior to this last incision was raised in the flap so formed. The pyriformis, which was not visible, was divided extrapelvically and a pair of Moynihan's cholecystectomy forceps passed from within the pelvis to emerge through the greater sciatic foramen and used to draw a Gigli saw into position for dividing the ilium. An appropriate area of the ilium was cleared of the iliacus and the bone sawn through from the greater sciatic notch.

The sacrotuberous and sacrospinous ligaments were next divided and the innominate bone allowed to rotate laterally, giving a wide exposure of the pelvis. The psoas and femoral nerve were divided at the pelvic brim; the sciatic and obturator nerves were divided, the limb allowed to fall further laterally, to be freed by division of branches of the gluteal and internal pudendal vessels and of the levator ani.

The wound was closed by suturing the gluteal fascia to the anterior abdominal muscles over a corrugated drain and the skin closed in three flaps. (*Fig.* 322.)

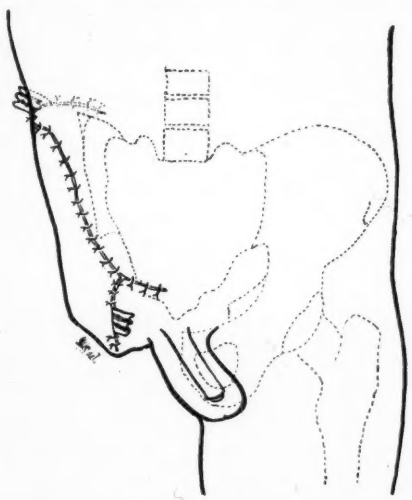

FIG. 322.—The amputation completed.

The time occupied by the operation was 1 hour 25 minutes. 1600 c.c. of stored citrated blood were given during the operation, but, despite this, the blood-pressure fell to 90/85. One hour later, after a tidal drainage system had been erected and a further infusion of 560 c.c. of blood given together with routine anti-shock treatment and 15 mg. of intravenous methedrine, the patient was considered fit to be transferred to the ward. A further 560 c.c. of blood and 400 c.c. of plasma were given by infusion at 50 drops per minute, and in six hours the blood-pressure rose to 100/88. Hæmoglobin 80 per cent Haldane.

PROGRESS.—

July 12: First re-dressing under gas and oxygen. The wound was quite clean. The through-and-through drain was taken out and the lower drainage tube left in. Blood-pressure 120/78. Hæmoglobin 80 per cent Haldane.

July 19: All stitches had been removed by this date. A sulphanilamide powder dressing was applied, except in the lower part of the wound where there was a slight infection with *B. pyocyaneus*. This area was treated with ½ per cent acetic acid.

Aug. 10: Wound completely healed. The patient was up and about on crutches, and was sent to see Mr. Langdale Kelham, of Queen Mary's Hospital, Roehampton. He gave the opinion that no satisfactory prosthesis was available for this extensive amputation.

X-ray Report (Aug. 22): "The right side of the pelvis has been removed, except for a portion of the ilium bordering on the right sacro-iliac joint. The parts removed include the whole of the pubic bone and ischium on the right side. The coccyx is deviated to the left."

DISCUSSION

Certain points of technique are of considerable interest in an operation of this size. Gordon-Taylor (1935; 1940), who has recorded the largest individual series of cases, lays great stress upon certain precautions. He advocates adequate preparations for transfusion, gentle turning of the patient during operation, and sawing of the ilium rather than sacro-iliac disarticulation. He stresses the blocking of nerves before division and an incision such as Hogarth Pringle's (1916) modification of Girard's (1895) incision to give well-planned flaps with adequate blood-supply. We found the gluteal flap entirely satisfactory; but found it unnecessary to follow the detail of Assali and Sohier (1937). By using an oblique supine position for the patient, turning during the operation was avoided, though this advantage is also claimed by King and Steelquist (1943) for the lateral position. Subperiosteal dissection of the bulb is undoubtedly a time-saving manœuvre where possible. Tidal drainage of the bladder overcomes post-operative retention, avoids distension, reduces risk of infection, and re-educates the bladder to perform its normal function. An obvious defect in the operation described is the double division of the femoral nerve and the gross shock caused by division of the femoral, sciatic, and obturator nerves within a few seconds of each other. This difficulty could be overcome by procaine injection of the nerves before division (Gordon-Taylor and Wiles, 1935).

The indications for an operation as radical as this are limited: malignant disease involving the proximal portion of the thigh, hip, or innominate bone is the usual indication. It may very occasionally be considered in chronic osteomyelitis or tuberculosis of the hip which does not respond to conservative measures. It is unlikely to be of value in severe crushing or mutilating injuries such as those seen in war casualties, owing to the severe degree of shock already present.

We are greatly indebted to Mr. J. B. Hume for permission to publish this case, and for the help and encouragement which he has given to us in preparing this account. We should also like to express our thanks to Dr. G. T. Loughborough, of the Radiological Department, and to Dr. A. G. Stansfeld, of the Pathological Department, St. Bartholomew's Hospital.

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SPONTANEOUS RUPTURE OF THE SPLEEN IN SARCOIDOSIS

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SPONTANEOUS rupture of an apparently normal spleen, although rare, is a well-recognized entity. The literature has been reviewed recently by Jones (1944), and previously by Hamilton Bailey (1930) and Susman (1927). The case to be described was considered to belong to this group until histological examination revealed the characteristic picture of sarcoidosis. Spontaneous rupture of the spleen in in this disease has not hitherto been reported.

CASE REPORT

HISTORY.—J. B., a man of 49, was awakened on Sept. 20, 1944, by an 'alert'. Ten minutes later, while sitting up in bed, he had severe epigastric pain which radiated to each iliac fossa. It was followed by vomiting which increased with the pain until his admission, 36 hours later. He gave no history of injury or of indigestion. A year before, he had been in hospital with pneumonia, and for 16 years he had been a victim of winter bronchitis.

FIG. 323.—Cut surface of spleen showing multiple hæmorrhages and tear in the capsule. (× ⅔.)

ON EXAMINATION.—He was a thin, pale, anxious-looking man. The pulse-rate was 96, temperature 99·6° F., respirations 22, and blood-pressure 120/90. The abdomen was rigid and tender all over. The liver dullness was normal, but shifting dullness was present in each iliac fossa. On auscultation there were normal peristaltic sounds and no transmitted sounds were heard. On rectal examination tenderness anteriorly was found. General examination was negative apart from the signs of chronic bronchitis. A pre-operative diagnosis of peritonitis of obscure origin was made.

AT OPERATION.—Laparotomy revealed a large amount of fluid and clotted blood in the peritoneal cavity. The source of the bleeding was found at the upper pole of the spleen. Here there was a tear in the capsule from which blood-clot protruded. The spleen was not enlarged and was not unduly mobile. A blood transfusion was given and splenectomy performed. Examination of the other abdominal viscera revealed no abnormality.

The post-operative period was characterized by a pyrexia ranging from 99° F. to 102° F. No cause could be found to account for this, and after five weeks it returned to normal.

THE SPECIMEN (*Figs.* 323, 324).—After removing blood-clot, a deep tear was found in the outer aspect of the upper pole. There were small subcapsular hæmatomas in the upper and lower poles. The capsule was not thickened. The cut surface was brownish-red in colour, mottled by several hæmorrhages of varying size in the substance of the spleen. One of these involved the whole transverse diameter of the spleen and was undoubtedly the cause of the tear in the capsule by bursting through to the surface.

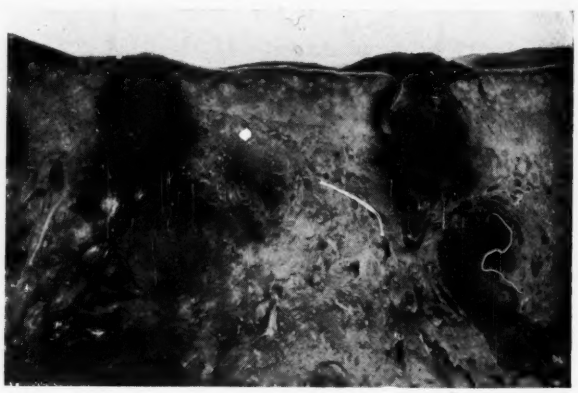

FIG. 324.—Closer view of cut surface of spleen showing subcapsular hæmorrhage.

HISTOLOGICAL EXAMINATION. (*Figs.* 325–327).—The capsule does not show thickening or inflammatory changes except in an area where the splenic parenchyma appears to be replaced by extensive hæmorrhage. In this area there are remnants of trabeculæ and one focus consisting of large epithelioid cells in the actual capsule. The rest of the splenic parenchyma shows rather atrophic pulp with large patent sinuses which are almost empty —containing only a few red blood-cells and some mononuclear elements. Most of the Malpighian corpuscles contain epithelioid cell nodules very much like miliary tubercles, but without proper caseation; instead there are deposits of hyaline material in the centre of some of these nodules. There are in addition a fair number of giant cells in these nodules. These are of the type of the so-called juvenile Langhan's cells, i.e., small in

size and with the nuclei, small in number, often in the centre, or irregularly distributed throughout the cell.

A feature of special interest is the presence of a fair number of nodules in the intima of large sinuses and veins. In many of these vessels a number of granulomata are present—in one lumen seven were found. It is worthy of note that in addition to the granulomata plasmatic fibrinous clots had formed in these vessels. Staining of the collagenous fibres shows some of the nodules with marked fibrous proliferation. In these sections it could be seen that the hæmorrhages were not confined to the subcapsular regions, but had involved parts of the actual splenic parenchyma, remnants of which were discovered in outline by means of stains for

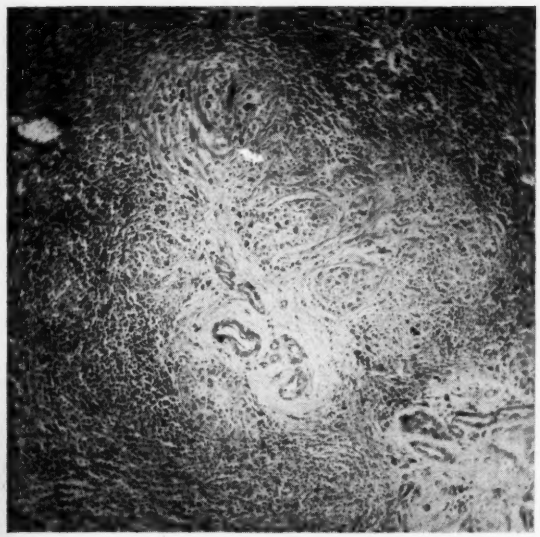

FIG. 325.—Survey of spleen showing a system of Malpighian corpuscles replaced by nodules of the Boeck type. (× 60.)

elastic fibres. Acid-fast stains did not reveal the presence of tubercle bacilli. The histological features are those of non-caseating tuberculosis of the type of Boeck's sarcoidosis.

SUBSEQUENT INVESTIGATIONS.—Although there were no clinical signs of the disease, the histological diagnosis of sarcoidosis stimulated a search for further evidence, with the following results :—

Lungs: The sputum was repeatedly negative for tubercle bacilli. Radiography showed a little enlargement of the hilar glands but no evidence of fibrosis of the lung parenchyma.

Bones: X-ray examination of the phalanges, metacarpals, metatarsals, and the long bones showed no cystic areas and no osteoporosis.

Eyes: The vision was 6/6 in each eye. No folliculoid formations were found in the iris or ciliary body and no nodules in the conjunctiva.

Skin: No skin lesions were found.

Lymph and Salivary Glands: No abnormality was found in the salivary glands and the lymph-glands that were palpable were not enlarged.

Blood: Red cells, 5,160,000.
White cells, 4000.
Neutrophils, 51 per cent.
Eosinophils, 4 per cent.
Lymphocytes, 34 per cent.
Monocytes, 11 per cent.
Platelets, 180,000. Hæmoglobin, 77 per cent.
Colour index, 0·75.
Sedimentation rate, 50 mm. in 1 hour.
(This rise in sedimentation rate a month later had fallen to 15.)
Total serum proteins, 6·25 per cent.
" " albumin, 3·8 per cent.
" " globulin, 2·45 per cent.
Blood Wassermann, negative.
Repeated blood-cultures were negative.

FIG. 326.—A large vein showing a nodule of the sarcoid type in the intima. (× 72.)

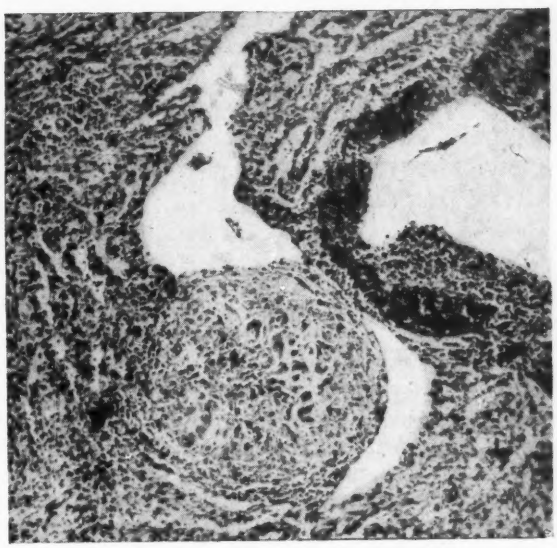

FIG. 327.—A nodule of the sarcoid type with juvenile giant cells. (× 160.)

Mantoux reaction 1/10,000, 1/1000, 1/100, were all negative; 0·01 mg. of vole bacilli (an avirulent acid-fast strain occurring in tuberculosis of voles) was injected intradermally, and after an interval of six weeks the Mantoux test was repeated. It remained negative.

This is in conformity with the work of Lemming (1940), who found that B.C.G. injection would fail to turn a negative Mantoux into a positive one in patients with Boeck's sarcoid in contrast to ordinary Mantoux-negative persons.

Subsequent History of the Patient.—The patient has been kept under observation for nine months. He has remained in good health since the operation and has not developed any clinical or radiological evidence of sarcoidosis. His blood-sedimentation rate is now 3mm. in 1 hour and his blood-count is within normal limits.

DISCUSSION

Sarcoidosis is a disease which affects mainly the reticulo-endothelial system, with the formation of follicles resembling those found in tuberculosis, but with no tendency to caseation. The lungs, lymph-glands, liver and spleen, skin, and the small bones of the hands and feet may be involved together or in various combinations. The course is protracted, with continued fever and usually a high sedimentation rate, but the disease tends to regress spontaneously, the lesions healing by hyalinization and fibrosis. Although there is a close resemblance to tuberculosis, the lesions do not caseate, acid-fast bacilli are not found, and the Mantoux reaction is usually negative. The Mantoux reaction remains negative in spite of sensitization either by heat-killed tubercle bacilli or by live avirulent acid-fast bacilli. In a normal person these would convert a negative Mantoux into a positive one.

Splenomegaly is often a prominent feature and was present in 7 out of 13 cases reviewed by Snapper (1938). Although the splenomegaly is often of secondary importance when the disease is generalized, it may be obtrusive enough to warrant splenectomy, as reported recently by Cameron and Dawson (1942). Punctate hæmorrhages throughout the substance of the spleen were found in their case. In our case similar hæmorrhages were present, and it is probable that they are caused by the vascular changes, including the tendency to thrombosis already described. When a vessel of suitable size is involved the hæmorrhage may be sufficient to rupture the capsule of the spleen, causing intraperitoneal hæmorrhage.

SUMMARY

A case of sarcoidosis with spontaneous rupture of the spleen is described. No involvement of the other organs was found. The underlying pathology was found only on microscopical examination of the removed spleen.

We are indebted to Dr. E. Nassau for obtaining the vole bacillus, and to Dr. Walter Pagel for the pathological investigations and for his criticism and advice.

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THE M.E.M. SPHYGMOSCOPE IN VASCULAR INJURIES*

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IN the work of a Vascular Injuries Centre we have found that serial blood-pressure readings are often a great help in determining the actual vessel involved in a traumatic false aneurysm or arteriovenous fistula; in assisting to estimate the size of the hole responsible for an arterial leak; in providing some guide to the progress of the development of the collateral circulation before and after any ligature operation; and finally in demonstrating the degree of patency or otherwise of an artery after a suture operation.

The signs elicited by ordinary clinical examination of a patient suffering from an arterial lesion are sometimes misleading. For instance, the presence of a swelling and a full cycle murmur and thrill in Scarpa's triangle may suggest an arteriovenous fistula between the superficial femoral vessels when actually the profunda vessels are involved. By recording the blood-pressure in the limb distal to the lesion a correct diagnosis can often be made; for should the pressures be only slightly below those in the same segment of the normal limb it is probable that the profunda vessels are involved, but should the pressures be much impaired the lesion probably affects the superficial vessels. Similarly, a wide fistula between main limb vessels is found to produce a bigger drop in pressures beyond the lesion than a narrow one, and with the knowledge of these pressures one is frequently enabled to foresee unexpected difficulties at operation and plan accordingly. The diagnosis, however, is also influenced in varying degree by other factors, such as the effect on the pulse-rate of obliteration of an arterial leak, but a recording of the blood-pressures is, nevertheless, important.

Various factors combine to limit severely the applicability of the usual auditory method of blood-pressure estimation in this work. Amongst the most important may be mentioned:—

1. The need in many cases for taking the measurements on the distal segment of the limb, where no satisfactory artery for auscultation exists.

2. The frequent presence of so loud a murmur as to make auditory estimation impossible, even where an artery is easily available for auscultation.

A visual method is thus essential in many cases. There are various forms of oscillometer which give visual indications, and probably the best of these

* Read at a meeting of the Vascular Injuries Subcommittee of the Medical Research Council on March 27, 1945.

machines is the Recklinghausen oscillotonometer (von Recklinghausen, 1906, 1907). We have used one but found it insufficiently consistent and reliable. Amongst its outstanding disadvantages were :—

1. So-called 'edge effects', when estimating systolic pressure. These are small oscillations due to the impingeing of the blood-stream impulses against the edge of the upper cuff, which appear before the true oscillation and vitiate the accurate determination of its appearance.

2. The difficulty of estimating accurately the amplitude of the oscillations of a pointer moving round a scale.

3. The impossibility of estimating really low diastolic pressures with any degree of accuracy.

4. The wide margin of error generally, shown by the inconsistency of rapidly consecutive readings.

The apparatus was therefore abandoned and trials were instituted with the latest apparatus for visual estimation of blood-pressure—the M.E.M. sphygmoscope.

This machine and its principles have been fully described by Evans and Mendelssohn (1942) and Mendelssohn, Evans, and Mallinson (1943; 1945). Briefly, two cuffs are employed (*Fig.* 328, S, D).

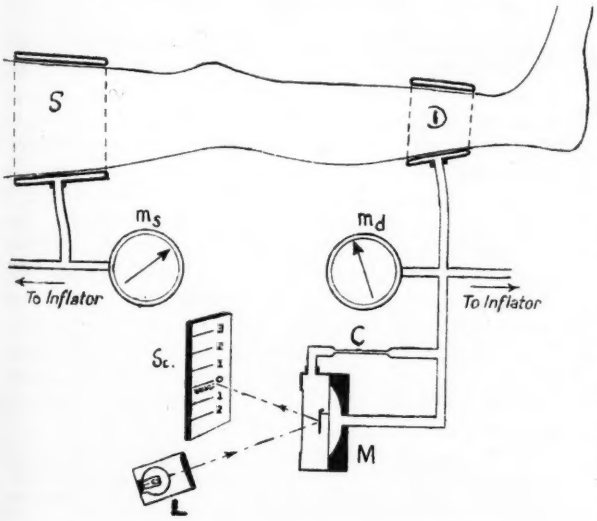

FIG. 328.—Diagrammatic representation of the M.E.M. sphygmoscope.

Each is connected to an aneroid manometer (Ms, Md), which records the pressure in it in mm. Hg. Each cuff can be inflated independently. A highly sensitive membrane manometer (M) is connected only to cuff D. This manometer M carries a mirror which reflects a bar of light from a source (L) on to an illuminated and graduated scale (Sc). Thus any pulsations in cuff D are greatly amplified and clearly and faithfully reflected on the scale Sc. The two chambers of the manometer M on each side of the membrane are connected by a capillary (C) to ensure that both are at the same mean pressure.

If the distal cuff D is inflated to a pressure above diastolic but below systolic pressure, relatively large, sharp, and jerky oscillations will be received by the manometer M from the cuff D and reflected highly amplified on the scale Sc. The character of these oscillations is as described because the artery beneath the cuff is completely collapsed in diastole owing to the pressure in the latter being above the diastolic pressure in the former. If now the pressure in D is slowly released there comes a point at which an abrupt change in the character of the oscillations observed occurs. The pulsations are reduced in size by nearly 50 per cent and become smoother and more gentle. The reason for this is that the pressure in the cuff D is now at or below the diastolic pressure in the artery and the latter does not collapse in diastole but pulsates in an even and elastic manner with the now continuous flow of blood through it. The point of change in the character of the oscillations is the diastolic end-point and can be read on the manometer Md.

If the proximal cuff S is now inflated (leaving cuff D at any convenient pressure below diastolic) to a pressure above systolic, no impulses at all can reach cuff D and the light bar remains motionless. If cuff S is now slowly deflated, at a certain point pulsations will again commence to reach cuff D and will be reflected as oscillations of the light bar on scale Sc. This occurs at the point at which the pressure in cuff S is at systolic pressure, and thus the systolic pressure can be read on the manometer Ms.

The light bar oscillates always over the same area of the stationary scale Sc, thus enormously facilitating accurate observation. Controls (not shown in the simplified figure) on the apparatus provide for slow and perfectly even release of pressure, which can be instantaneously checked at will. Thus the readings of pressure can be made on the manometers Ms and Md while their needles are held stationary at the estimated end-point, thus further lessening the possibility of error.

Using this apparatus on a considerable number of patients suffering from traumatic aneurysms, arteriovenous fistulæ, and other arterial lesions, we have found it very easy to read. The systolic end-point is very sharp, vibration due to murmurs is minimal, and the diastolic end-point is much more definite than hitherto. This last has been particularly evident in estimating really low pressures.

Measurements in the region of 50/40 mm. Hg (measurements previously found to be virtually impossible) have presented little or no difficulty. The consistency of readings is very high, as has been repeatedly demonstrated by one of us checking the other's measurements immediately, but without having previous knowledge of them. The discrepancy has never been more than 2–3 mm. Hg.

Estimations can be made just as easily on the forearm or lower leg as on the upper arm or thigh.

Although it is possible that the actual figures obtained may not be those of the actual arterial blood-pressure, they are at the very least as accurate as with auditory methods, and certainly more accurate than the latter in respect of the diastolic pressure, the end-point of which is still controversial to-day; and in any event the exact value is immaterial. For clinical purposes it is the reliability and consistency of the observations of the rise and fall of pressures which is really essential, and in this respect the M.E.M. sphygmoscope has been found to be excellent.

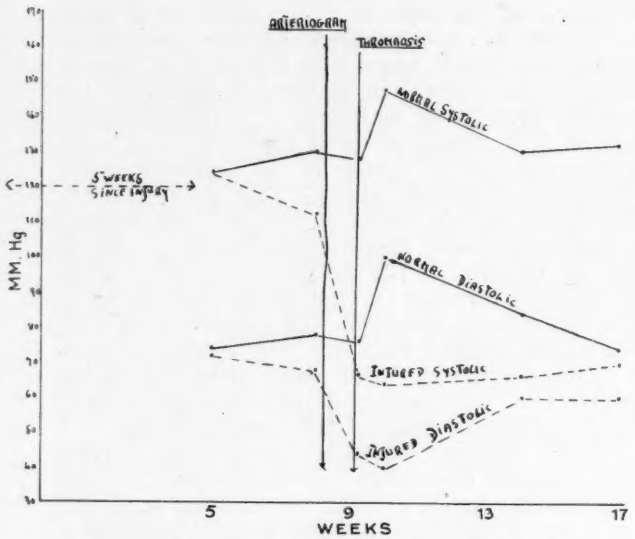

FIG. 329.—*Case* 1, *J. C., aged* 35. Effect of thrombosis of popliteal artery and sac of false aneurysm, following injection of pyelectan for arteriography.

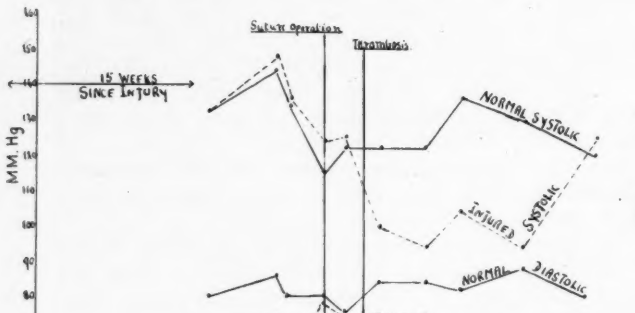

FIG. 332.—*Case* 4, *P. A., aged* 19. Effect of thrombosis seven days after suture operation for a popliteal varicose aneurysm. Repair necessitated two separate suture lines on artery, thus adding to danger of subsequent thrombosis.

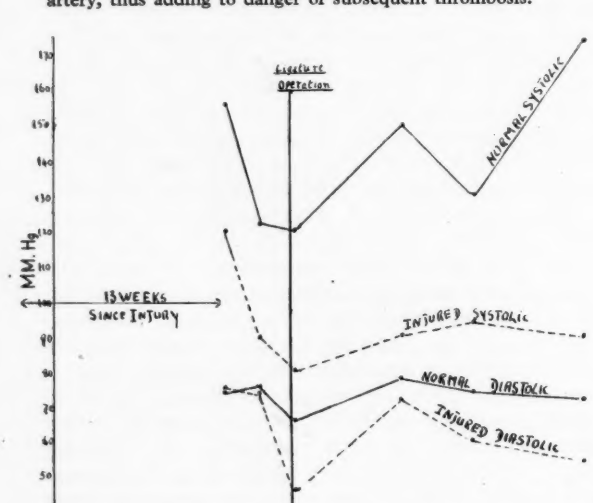

FIG. 333.—*Case* 5, *F. H., aged* 19. Immediate increase in fall of pressures after ligature operation for a false aneurysm at junction of superficial femoral and popliteal arteries.

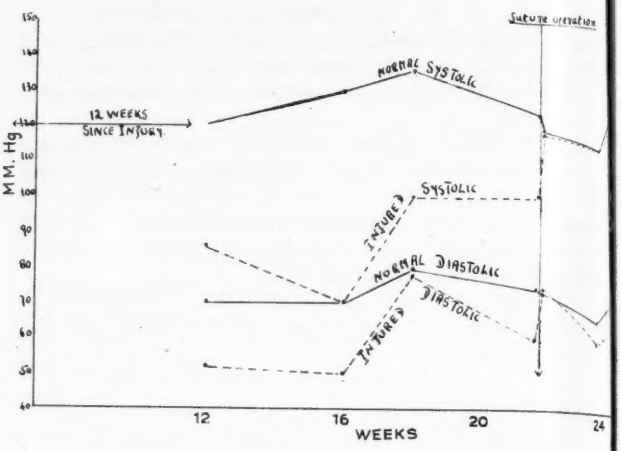

FIG. 330.—*Case* 2, *J. T., aged* 19. Restoration of blood-pressures in distal segment of limb to approximately normal, following successful suture operation for a popliteal varicose aneurysm.

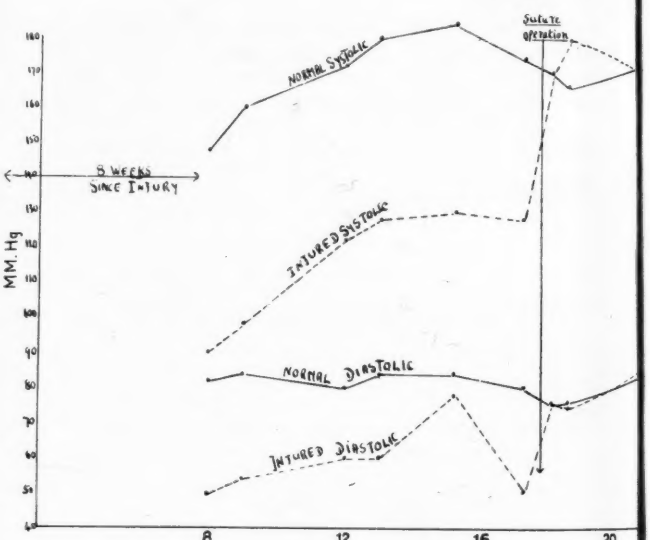

Fig. 331.—*Case* 3, *A. L., aged* 18. Result of successful suture operation in a varicose aneurysm of the superficial femoral vessels. Large hole found in artery at operation, hence big difference in pressures before operation.

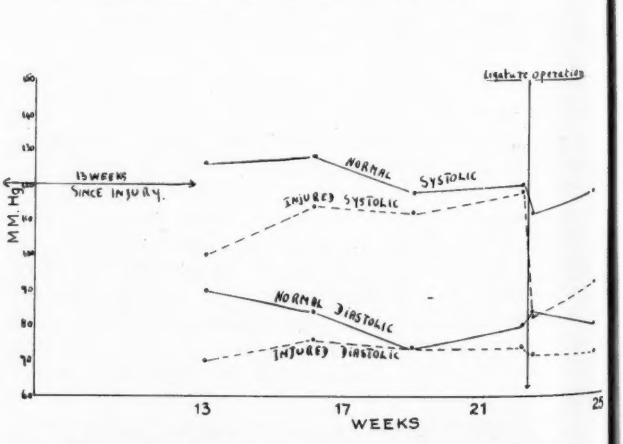

FIG. 334.—*Case* 6, *F. H., aged* 21. Shows gradual rise in pressures associated with development of collateral circulation in a case of varicose aneurysm of the first part of the axillary vessels, and subsequent drop after ligature operation.

The accompanying charts (*Figs.* 329–334) are illustrative of the type of work done on these cases with the apparatus.

SUMMARY

Serial blood-pressure readings are of considerable assistance in the field of vascular surgery, and trials with the M.E.M. sphygmoscope have shown it to possess the following advantages over other methods of estimating them :—

1. Both systolic and diastolic pressures are clearly and easily estimated *visually*.

2. Measurements are made just as easily on either upper or lower limb and on any part of them.

3. Measurements of very low pressures, particularly with low pulse pressures, present little or no difficulty.

4. Independent readings show a high degree of consistency.

Our grateful thanks are due to Mr. B. C. Maybury for much valuable help and advice, and to Mr. B. C. Maybury, Mr. A. Innes, Mr. C. P. Sames, and Mr. J. White for permission to obtain material for charts from the cases under their care.

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THE RELATIVE INCIDENCE OF STERNOMASTOID AND OCULAR TORTICOLLIS IN AIRCREW RECRUITS

BY J. GRIEVE, SQUADRON-LEADER, R.A.F.V.R.

OCULAR torticollis can be broadly defined as a tilting of the head occurring in association with hyperphoria. On this basis a wide range of head tilting and of hyperphoria is possible. Binocular vision and facial asymmetry may or may not be present, but in all cases the conjugate ocular movements are abnormal. Professor Mann (1944) does not consider that all cases falling in the above classification should be labelled as ocular torticollis. She states that, " to diagnose true ocular torticollis we have considered that the tilt should be present all the time and should be practically lifelong, that the movements should be abnormal, that a vertical squint should be apparent with the head erect, and that the patient should be binocular only in the tilted position." Those not fulfilling these criteria are classed as head tilting associated with hyperphoria.

The present series includes both Professor Mann's categories. In every case the head tilt was constantly present, and was one of the features drawing attention to the condition.

Most surgical text-books devote a section to sternomastoid torticollis, but dismiss the ocular variety in a few words. Lyle and Jackson (1940) state that sternomastoid torticollis is considered to be more common, while in the latest edition of Mercer's *Orthopædic Surgery* (1943) only passing reference is made to an ocular aetiology. In the course of examining 9500 recruits for flying duties, 2 cases of sternomastoid and 16 of ocular torticollis have been found. No spasmodic cases have been seen. The group examined had a mean age of 21 years, with a standard deviation of the order of 4·5 years. The only definite selective factor at work was the preference for flying duties expressed by these young men.

FEATURES OF THE CASES

Sternomastoid.—Both were typical, the one showing a head tilt of 10–15° and the other 20°. The facial asymmetry was more marked in one than the other.

Ocular.—In this group the degree of head tilt varied between 5° and 15°, and the hypertropia ranged from 2·5 to 20 prism dioptres or more. Three of the ocular cases showed definite facial asymmetry, and all had abnormal conjugate movements. One case, described below, demonstrates the importance of differential diagnosis.

Case.—H. M., aged 18½ years, was a draughtsman who had always had a head tilt of 10–15° to the left. Nothing was known of his obstetric history, and, so far as he knew, the head tilt had always been present. Six years previously he had had a tenotomy of the left sternomastoid, but no benefit resulted.

ON EXAMINATION.—There was a 10–15° head tilt to the left with a mild degree of facial asymmetry. The tilt could be corrected voluntarily. His visual acuity was 6/6 in each eye, and the cover test showed that he had a marked R/L vertical squint—in fact, the right eye suppressed and could not be depressed below the horizontal. No reading could be obtained on the Maddox rod or the Maddox wing, and it was impossible to demonstrate any stereoscopic vision using the Livingston rotating stereogram. The conjugate ocular movements were distinctly abnormal.

DIFFERENTIAL DIAGNOSIS

This has been fully described by Lyle and Jackson (1940), and is best summarized in tabular form (*Table I*).

It will be seen from this that if the possibility of an ocular basis is not considered, there is a strong possibility that an ocular torticollis might be treated as a sternomastoid, as happened in the case described above.

DISCUSSION

So far no clue has been found as to the reason for the general belief that a sternomastoid torticollis is much commoner than the ocular variety. One

Table I.—DIFFERENTIAL DIAGNOSIS OF STERNOMASTOID AND OCULAR TORTICOLLIS

DIFFERENTIAL FEATURE	STERNOMASTOID	OCULAR
1. Head tilt	Obvious	Not so obvious
2. Sternomastoid	Contracted	Not contracted
3. Head position	Not possible to straighten passively	Passive straightening possible
4. Position of face	Away from side of tilt and looking up	Towards side of tilt and looking down
5. Conjugate ocular movements	Normal	Abnormal
6. Extrinsic ocular muscle balance	Good	Shows hypertropia or hypotropia
7. Facial asymmetry	Marked	Less marked or absent

possible explanation of the present reversal of the ratio is that the incidence of ' sternomastoid tumours ' is declining as the result of improved obstetrics, while more cases of ocular torticollis are being recognized. The sufferer from an ocular torticollis can correct his deformity at will, and, in the absence of a detailed ocular examination, is more likely to be missed than is the sufferer from a sternomastoid contracture.

A ratio of 8 ocular to 1 sternomastoid torticollis discovered in examining nearly 10,000 young adults seems most unlikely to be due to chance. Further information has been obtained relating to the incidence of torticollis in general. Among 11,805 orthopædic cases seen in the 10-year period 1929–1938 at clinics run from the Wingfield-Morris Orthopædic Hospital, Oxford, 111 cases of torticollis of all kinds were seen. This figure comprised 108 sternomastoid cases, 1 spasmodic case, and 2 hysterical cases. No case of ocular torticollis has been seen. In 1944 at the Oxford Eye Hospital 18 cases of ocular torticollis conforming to the general description were seen; while at Reading Eye Clinic, out of 6979 cases seen in 1938–40, 17 cases of torticollis occurred—2 sternomastoid and 15 ocular. These findings are summarized in *Table II*.

The most interesting feature of this table is the close similarity between Squadron-Leader Cashell's figures at Reading and those of the present series. This may well be chance in view of the fact that the cases at Reading were a much more selected group. It seems appropriate, however, to draw attention to ocular muscle imbalance as of more than academic interest in the aetiology of torticollis. In the absence of a readily demonstrable sternomastoid contracture, a careful examination of the ocular muscle balance is indicated.

SUMMARY

In the course of examining 9500 recruits for fitness for flying duties, 2 cases of sternomastoid torticollis have been found and 16 cases of ocular torticollis. A possible explanation of this reversal of the usually accepted ratio of the two conditions is advanced, and a plea is put forward for the better recognition of ocular muscle imbalance as an aetiological factor in torticollis.

Table II.—INCIDENCE OF TORTICOLLIS

CLINIC	TOTAL CASES	TORTICOLLIS			
		Sternomastoid	*Spasmodic*	*Ocular*	*Hysterical*
Wingfield-Morris, 1929–1938	11,805	108	1	0	2
Oxford Eye Hospital, 1944	6,902	0	0	18	0
Reading Eye Clinic, 1938–1940	6,979	2	0	15	0
Present series	9,500	2	0	16	0

I am indebted to the Director-General of Medical Services for permission to publish the Royal Air Force material, and to Professor Ida Mann, Professor H. J. Seddon, and Squadron-Leader G. T. W. Cashell for putting their records so freely at my disposal.

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In Memoriam

JAMES SHERREN

(1872-1945)

WITH the death of James Sherren, at the age of 73, there passes one of the great figures of English surgery, a man of strong character, of great ability, and an attractive personality. His life was one of adventure, of hard work, of romance, and of unusual and rapid success.

Born by the sea at Weymouth, he early showed a love of the seafaring life and in his youth served before the mast. One can imagine that even in these early days he possessed an unusual determination and strength of character for he rapidly rose and obtained a master's certificate while acting as

mate in one of the great shipping lines. Before he had gained a ship of his own, however, he suddenly decided to leave the sea and to enter the medical profession. What dominant factor compelled him to make this unusual decision is unknown; his action was apparently as sudden and determined as was his decision in later life to abandon surgery at the height of his career and at a moment's notice. He never lost his love of the sea. In more confidential moments he delighted to recount the hardships of his early life and the adventures of his various trips. Nor did he lose his interests in ships, his knowledge of which was encyclopædic, so that at a moment's notice he was able to tell one the position and date of sailing of any ship.

In the profession of surgery his career had no setbacks. He qualified at the London Hospital in 1899 and took the F.R.C.S. the next year. Three years later he was appointed Assistant Surgeon while still only 30 years of age—a record of rapid progress which has remained unbroken. During his period as Surgical Registrar he was a driving force to all his students, he knew them all and controlled their work and note-taking with strict discipline, so that we all feared his frequent rounds and the short and forcible notes left in his wake, but we all recognized his ability and his justice and rejoiced on his appointment to the staff. Incidentally, his quick progress and the success dependent upon his great ability is even now a strong argument in favour of having a portal of entry into medicine which is non-academic. If it had been necessary for Sherren to pass through a university, surgery would probably have been robbed of one of its leading lights.

Perhaps he was fortunate in having started the practice of surgery at the time of its most rapid development; but his strong and forceful character would have led to speedy advance in any profession. His knowledge of his subject was wide and detailed and his conclusions always definite. There was never in his mind any doubt of the line to be pursued, and his clear exposition, his confidence, and his manual dexterity made him a popular teacher and soon brought him a great reputation. In addition, he showed a clarity of thought in research which, when directed, in conjunction with the late Sir Henry Head, to the subject of the distribution of sensory nerves and the treatment of nerve injuries, gave him world-wide fame. Later his interest focused on abdominal surgery, and it is as one of the pioneers of modern gastric surgery that he will be remembered. His leadership and his operative ability in this branch were shown by the fact that his theatre was always filled with visiting surgeons from every country. His private practice grew rapidly, but he never allowed it to interfere with his hospital work. At this time I not only had the good fortune to be his hospital Registrar, but also acted as his private assistant and soon learnt to have a great admiration for his work. As a man one of the most impressive points in his character was the change from his rather abrupt manner to one of the greatest gentleness and kindness when talking to an ill patient. Never in his whole career was he late for any appointment. He worked rapidly and neatly, but although he was quick and decisive, there was never any haste or flurry. He always gave the impression that he knew precisely what he was going to do and set out to do it with speed and efficiency.

Professional recognition and honours came to him quickly. Erasmus Wilson Lecturer in 1906, he was elected to the Council of the Royal College of Surgeons in 1917, being Hunterian Professor in

JAMES SHERREN
(1872—1945)

1920 and Bradshaw Lecturer in 1925. He served for two years as Vice-President of the College. In the last war he was Consulting Surgeon to the War Office and Colonel, A.M.S., at this time doing the greater part of the surgical work at the King Edward VII Hospital for Officers. He was Examiner for Surgery at London University and for Anatomy in the Primary Examination for the F.R.C.S., and he was also a Member of the University Senate.

Then, in 1926, when at the height of his fame and career, when he had gained a reputation, not only in England but throughout the civilized world, which he shared only with Lord Moynihan, and when his way was clear to even higher honours, he suddenly announced his intention to retire. Within a few days he had resigned from the Council and from the London Hospital, had sold his house and cars and had severed all his professional connexions. Just as his entry in medicine, so was his retirement. What was the overwhelming urge

no one knows: probably he felt again the call of the sea and was determined to answer it while still of an age to enjoy it. More than most he must have felt—

"I must go down to the sea again, the lonely sea and the sky
And all I ask is a tall ship, and a star to steer her by."

He could at any rate leave surgery with the satisfaction of knowing that seldom if ever had any man accomplished so much and advanced so far in the short thirty years he had devoted to it.

Retiring to his place in the country overlooking Poole Harbour and the sea he loved, he found that even here he was unable to rest on land, and he went back to work as a ship's surgeon, where his great reputation enabled him to do much to better the conditions of the Marine Medical Service.

Sherren was a man who owed his advancement to sheer ability and strength of character; and although of a naturally shy and retiring disposition so that he hated making a public speech, he always stood out by the honesty of his work and the reliability of his opinions. In spite of his discipline and of his scorn of slackness which made him feared by those who did not know him, he soon endeared himself to those who had the privilege of working under him. With his death there is lost to us a great surgeon, a fine and romantic figure of a man, and a lovable personality. His name will rank high even on the distinguished roll of Dorset men. While England breeds such men her position in the mercantile marine and in surgery remains assured. Sherren has made his last voyage, but if it be true, as Confucius says, and as I think we all believe, that "Our bones shall moulder and rot in the fields, but the spirit issues forth and lives on high in a condition of marvellous brightness", then it is permissible to believe, nay, it is indeed probable, that the soul of this great man, this brilliant surgeon, and this fine character is not dead, but—

". . . . . has only passed
Further along a road whose sudden bend
Awhile has hid him from us, till at last
We reach our journey's end."

SHORT NOTES OF RARE OR OBSCURE CASES

A CASE OF SARCOMA OF THE LIVER

By F. D. SANER
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THE following case may be of interest since it presents one or two unusual features.

CASE REPORT

HISTORY.—R. P., a man aged 59. Except for operations as an infant to close a cleft lip and palate, this man gave no medical history; according to his statement he had enjoyed good health and led an active life until the onset of the present condition.

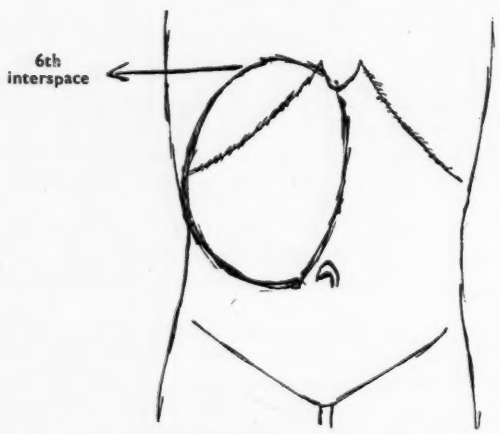

FIG. 335.—Diagram showing approximately the size and position of the tumour.

About the autumn of 1943 an increasing lassitude was noticed associated with gradual loss of weight and nocturnal frequency of micturition. During the spring of 1944 the abdomen began to swell and the bowels at this time were acting about a quarter of an hour after each meal, when the stools were bulky, very pale, and offensive; the appetite, however, remained good. Later, during July, swelling of the legs and ankles became marked, and this, together with increasing pain on lying on his back or right side, finally resulted in a decision to seek advice.

ON EXAMINATION.—The patient was tall and of spare build, with marked pallor of the face, breathlessness, and obvious loss of weight; the size of the abdomen and the swelling of the legs were immediately apparent.

A large tumour was found filling the upper right quadrant of the abdomen. The tumour, oval in shape, firm, smooth, rounded, and apparently solid, extended from above the costal margin to just below the umbilicus and back towards the loin (*Fig.* 335). On deep respiration the tumour moved over towards the left of the midline. Neither at the initial nor subsequent examinations was any evidence found of growth elsewhere.

Other investigations made were :—

Blood-sugar, 0·165 per cent
Blood-urea, 32 mg. per 100 c.c. of blood
Hb, 52 per cent. C.I., 0·56
R.B.C., 4,650,000 per c.mm.
W.B.C., 5600 per c.mm.
Lymphocytes 18 per cent, Eosinophils 8 per cent
Polymorphs 66 per cent, Basophils 0
Large mononuclears 8 per cent
Anisocytosis and poikilocytosis present, moderate.
No nucleated R.B.C.
Urine: S.G. 1020; acid; faint trace albumin; otherwise normal. All glandular areas normal.
Heart and lungs, C.N.S., limbs: nothing of note.

LAPAROTOMY (Sept. 21, 1944).—Right paramedian incision. When exposed, the mass had the dull whitish appearance of a thick-walled cyst, with numerous blood-vessels covering its surface, arising from the under surface of the left lobe of the liver. An exploratory needle was inserted into the tumour but nothing withdrawn; the wall, therefore, was incised, when a large quantity—about 25 oz.—of soft grey, friable tissue, somewhat resembling brain tissue, escaped, while the bleeding from the wall of the tumour was moderately severe. At this stage the patient was showing signs of shock, but after a pause while an intravenous plasma drip was commenced the condition improved. The wall of the tumour was separated from the structures of the posterior abdominal wall and finally delivered through a large opening in the gastro-hepatic omentum, which was tightly stretched over the mass, with the stomach pushed well over to the left of the abdomen. It was then found that the whole of the left lobe of the liver was involved, with a thin layer of liver substance (about $\frac{1}{8}$ of an inch) covering the dome of the tumour and a bridge of liver substance between this and a normal right lobe of the liver (*Fig.* 336). This bridge was

FIG. 336.—Photograph of tumour laid open. A, Layer of liver substance.

divided by means of a diathermy knife and the raw surface of liver closed so far as possible by means of catgut sutures. The opening in the gastro-hepatic omentum was repaired and after a rapid survey for any evidence of a possible primary growth, of which none was found, a drainage tube was inserted and the abdomen closed. A quite uneventful recovery was made and the man left hospital on the twenty-fifth day after operation.

PATHOLOGICAL REPORT.—The following report was made by Dr. P. O. Ellison, who has, too, kindly added a footnote on the condition: Tumour of the liver. Soft and white. Weight 68 oz. (this included most, but not quite all, of the contents of the tumour). A large, soft, rounded tumour, embedded in the liver; no obvious capsule but no visible sign of infiltration. The small portion of liver present shows no sign of cirrhosis and looks healthy. (*Fig.* 337.)

Microscopical: Histologically this is a classical example of spindle-celled sarcoma—with its elongated cells and vascular clefts—of an actively growing type.

FIG. 337.—Photograph of tumour showing its gross structure.

It has no capsule. The liver tissue is little affected, being slightly compressed near the growth.

Note.—Massive, solitary neoplasms of the liver, although perhaps not of extreme rarity, are decidedly uncommon; they are almost invariably malignant, and this specimen is undoubtedly so. Mere size is an insufficient guide as to whether the growth is primary or secondary, and though multiple growths would be expected if the tumour were a secondary, yet cases are on record of solitary massive sarcomas of the liver.

This growth appears to be a pure spindle-celled sarcoma, though, according to Ewing, a true spindle-celled tumour of uniform structure has yet to be reported (Ewing's *Neoplastic Diseases*, 4th ed.).

It is true that the vascularity of the growth described above might suggest a diagnosis of angiosarcoma, but the conspicuous histological feature is the solid spindle-celled structure.

PROGRESS.—During March, 1945, R. P. wrote to say that until mid-February he was making satisfactory progress, but then an attack of influenza had put him back and progress since then had been retarded. His main complaints, he wrote, were breathlessness and pain in the chest after walking or going upstairs, also that he was easily tired and latterly had gained no weight; on the other hand, he said he suffered no pain, was eating and sleeping well, that there was only very slight swelling of the ankles and feet, and the stools though rather light in colour were otherwise normal.

At the end of March he came to report personally, when again his pallor was a striking feature. On general examination nothing abnormal was detected except at the upper end of the laparotomy scar. In this position there was a small rounded moveable tumour immediately subcutaneous which was said to have appeared suddenly

three weeks previously; it was slightly larger and thicker than a sixpence and gave the impression of being semi-solid. Re-admission to hospital was advised with a view to treatment of the anæmia and for removal and examination of the small tumour. The blood-count was as follows:—

R.B.C.,	3,300,000 per c.mm.
Hb,	40 per cent
C.I.,	0·6
W.B.C.,	6800 per c.mm.
Polymorphs,	77 per cent
Lymphocytes,	15 per cent
Eosinophils,	5 per cent
Basophils,	1 per cent
Large mononuclears,	2 per cent

Anisocytosis and poikolocytosis marked.
Normoblasts, 34 per c.mm.

The small tumour of the abdominal wall when removed was mainly composed of soft, friable, greyish-looking tissue on which Dr. Ellison reported that "a small proportion of the tissue consists of spindle-celled sarcoma".

After two weeks in bed under treatment (Dr. E. G. B. Calvert) the patient had gained in weight and had considerably improved in appearance. On the seventeenth day after admission he complained of pain, though not severe, across the upper abdomen, was rather restless, and had depreciated again in appearance; nothing was found on examination. The next day there was an obvious though not copious melæna, soon after which the pulse started to fail and the pallor increased; R.B.C., 1,200,000 per c.mm. Hb, 20 per cent.

Death occurred some twelve hours later. Unfortunately a post-mortem examination was refused.

RUPTURE OF AN AXILLARY ANEURYSM THROUGH THE QUADRILATERAL SPACE*

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ANÆSTHETIC SPECIALIST
and Capt. N. C. WELPLY, R.A.M.C.
RESUSCITATION OFFICER

The following case seems worthy of record not only because of its rarity but also because of its great interest from the viewpoint of the treatment of severe blood loss and shock.

CASE REPORT

The patient, R. W., aged 18 years, a German prisoner of war, was admitted to the Field Vascular Centre on Jan. 18, 1945.

Previous History.—He was wounded by machine gun on Jan. 7 in the right shoulder and right lower jaw. Bleeding from one of the shoulder wounds was profuse and he lost consciousness. Before losing consciousness he noticed that he was unable to dorsiflex his right wrist.

At C.C.S., six hours after wounding, he was found to have: (1) Through-and-through wound of the right lower lip, with fracture of the mandible; (2) Entry wound to the right of the manubrium sterni and exit wound just lateral to the body of the right scapula. Anti-gas-gangrene serum and penicillin were given and a plasma drip was commenced.

Five and a half hours later, B.P. 120/80. Blood transfusion (1 pint) begun. Radiography shows foreign body at apex of lung and comminuted fracture of body of right mandible from $\overline{3}$ back to $\overline{8}$ which is involved on a separate fragment.

Operation, 29 hours after wounding, at Forward Facio-maxillary Unit: (1) Wounds of right hand incised and fragments of clothing removed. (2) Wounds of right sternoclavicular region and scapular region incised. Track disappeared deep to right clavicle. Slight hæmorrhage controlled by gauze and firm bandage. (3) Submandibular incision, loose bone fragments removed, drains inserted. Eyelets and I.M.F.

On Jan. 9 swelling of right arm noted.

Jan. 11, $\overline{7543}$ extracted and upper and two-piece lower splints applied with I.M.F. wires and elastic traction.

Jan. 12, i.e., 5 days after wounding, marked œdema of right arm and continuous thrill over the pectoral muscles (R). Tube for penicillin to anterior neck wound and 10,000 units instilled daily for three days.

On Admission to Field Vascular Centre, 11 days after wounding.—The right arm is grossly œdematous from the base of the fingers to the axilla. A continuous thrill is easily felt in the right infraclavicular area and is conducted over the upper chest wall, but not down the arm. Above the clavicle there is a thrill during systole only. The right subclavian artery is more easily felt and its pulsations more forcible than on the left side. There is a loud systolic murmur and a continuous rasping bruit maximal just below the clavicle and conducted proximally along the subclavian artery and along the carotids on both sides and distally to the cubital fossa. The right radial pulse is slightly diminished and is delayed. The skin of the right hand shows some rubor, but there are no other trophic changes. The hand is warm even after exposure to room temperature.

The heart is of normal size. No abnormal findings. P. 92; B.P. 135/90.

Blood Examination.—

Blood group, B.III. R.B.C. 3,600,000.
Hb = 98 per cent S = 12·15 g. per cent = 84 per cent H.
C.I. = 84/72 = 1·17 W.B.C. 12,000.
B.S.R. (47) corrected = 30 mm. in 1 hr.
Hæmatocrit 38 per cent.
Mean corpuscular volume = 106 cu. micra.
Mean corpuscular Hb = 34 mg.
Mean corpuscular Hb conc. per cent = 32 per cent.
Coagulation time = 3½ min.

It was considered that there was an arteriovenous lesion of the first part of the axillary artery and that the circulation to the upper limb was adequate for its resting needs. The œdema might be due to the result of the initial ischæmia or to venous obstruction. As there was no obvious sign of sepsis in the wounds it was hoped that conservative treatment would be followed by the development of a good collateral circulation

* From a General Hospital, C. M. F.

uncomplicated by secondary hæmorrhage. Peripheral nerve examination revealed a lower trunk brachial plexus lesion.

The œdema of the arm subsided steadily, but on Jan. 23 he became febrile. There was impaired percussion note with vesicular breath-sounds accompanied by crepitations at the right base. Sulphathiazole course begun.

The temperature subsided, but on Jan 30, i.e., 23 days after wounding, there was a slight hæmorrhage from the wound over the right scapula posteriorly. This was treated by firm dressings only as there was no swelling in relation to this wound and no pulsation while the axillary signs were unchanged.

On Feb. 1 there were two very slight hæmorrhages from the posterior wound, but again no pulsation or murmur.

On Feb. 2, at about 00.05 hr., there was a further hæmorrhage, again of small size, from the posterior wound. Under pentothal (G. L. F.), and with a plasma drip running, the wound lateral to the axillary border of the scapula was explored. Clot was gently removed and the wound found to lead through the quadrilateral space to a traumatic arterial hæmatoma of the axillary artery. A pack was inserted to control the hæmorrhage and blood transfusion was begun. As the pack controlled the hæmorrhage completely and did not impair the limb circulation it was decided to wait a few hours and then attempt what was bound to be a formidable operation from the front.

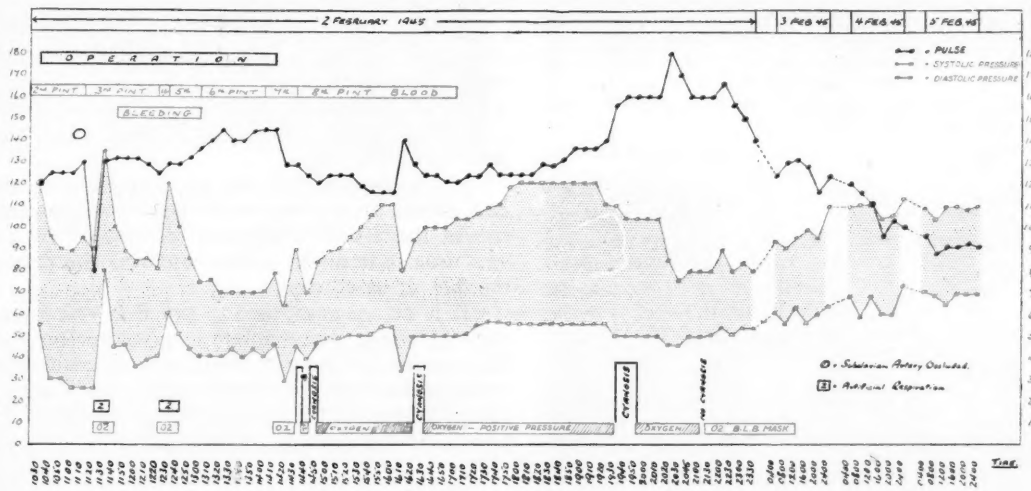

FIG. 338.—Operation chart.

OPERATION (J. J. M. B.).—On Feb. 2, with the second pint of fresh blood running, operation was carried out under pentothal and intrapharyngeal gas and oxygen (G. L. F.). An incision was made along the upper border of the medial two-thirds of the right clavicle and downwards over the clavicle into the delto-pectoral groove. Numerous dilated and distended veins were secured and the clavicular head of the sternomastoid was divided. The structures above the clavicle were matted together and dissection in the midst of a multiplicity of dilated veins was very difficult. The outer border of the scalenus anterior was identified and a large vein crossing it was divided between ligatures. The subclavian artery lay behind the clavicle and was difficult to reach, so the clavicle was divided. Retraction of the clavicle allowed the second part of the artery to be cleared and a tape loop was passed round it for temporary control of bleeding. This had no effect on the pulse or blood-pressure. Dissection was then begun below the clavicle by opening up the delto-pectoral groove. The pectoral muscles were divided and the costocoracoid membrane divided, exposing the wall of the false aneurysm and the grossly dilated vein obscured by fibrous tissue. The axillary artery distal to the lesion was of small size and was cleared and temporarily occluded by a tape loop.

As pulsation in the sac was absent following this proximal and distal occlusion, and the structures were firmly adherent to each other, the sac wall was opened and profuse bleeding and sucking of air occurred from a large hole in the axillary vein opening into the sac of the varicose aneurysm. This aperture allowed the aspiration of air, so the area was flooded with saline and a pack inserted. This controlled both the aspiration of air and the hæmorrhage.

It was now necessary to secure and ligate the axillary vein above and below the opening into it. There was so much fibrosis that dissection was hazardous and the vein was torn. Bleeding was severe and so the clavicle was rapidly disarticulated at the sternoclavicular joint and its inner portion removed. Dissection of the subclavian vein was begun in the scar tissue around the entry wound, but the vein was torn in the process and had to be tied at its junction with the internal jugular vein. There was still some bleeding from the proximal vein and this was found to be coming from the transverse scapular vein, which was ligated also. The axillary vein was freed distal to the fistula and ligated.

The sac was again inspected and found to be a large varicose aneurysm which was passing through the quadrilateral space, and the pack inserted from behind was identified and removed. The hole in the first part of the axillary artery was identified and the artery ligated above and below it and its division completed. There was still some bleeding from the venous opening and this was treated by occluding the opening by suture.

The wound was insufflated with penicillin-thiazole powder and three tubes were inserted for penicillin instillation. The posterior wound was also closed over penicillin tubes.

Condition at the end of operation which lasted 2 hr. 40 min. was very poor. Transfusion of fresh blood was continued throughout the operation, the transfusion being maintained at a speed as far as possible equal to the blood-loss. Circulation in the right arm was poor, but seemed no worse than that in the other limbs.

The Effects of Oxygen.—Operation concluded 14.10 hr. At 14.30 hr., as soon as oxygen under positive pressure was stopped, cyanosis was evident and the blood-pressure fell from 90/45 to 70/40. Similarly, when oxygen was stopped at 14.50 hr. there was immediate cyanosis and

oxygen was continued until 16.20 hr., when its cessation was again followed by cyanosis. Oxygen was therefore continued under positive pressure for another three hours and once again its cessation was followed by a gradually deepening cyanosis with a remarkable deterioration in general condition with rising pulse and a remarkable fall in pulse pressure (*Fig.* 338). Seven hours after operation positive pressure oxygen was stopped and there was no cyanosis so the patient was returned to bed, oxygen being continued by B.L.B. mask until 12.00 hr. the following day.

PROGRESS.—Blood-pressure and pulse became stabilized at 110/70 and 90 respectively three days after operation, and the patient made a reasonably rapid recovery.

The circulation of the right arm was never in doubt and there was no œdema following the venous ligation.

Intramuscular penicillin 15,000 units three-hourly up to 1,000,000 units was given and local instillation was continued for five days. There was no further hæmorrhage and there was only superficial breaking down of the wound. A small sequestrum was extruded from the lateral end of the clavicle on March 14, when the wound was clean with flat granulations and ready for grafting.

On Feb. 5, i.e., three days after operation, R.B.C. 3.600,000 Hb, 88 per cent S. = 75 per cent H., and colour index 1 approximately.

The peripheral nerve lesion was unchanged following operation and there were no superadded ischæmic changes. The loss of the clavicle did not seem to be much of a handicap.

On Feb. 24 there was no sign of union in the jaw, which was resplinted by Major Battle, and on March 17 the patient was transferred able to walk to Maxillo-facial Unit under the care of Major Battle. There was no murmur over the wound and no sign of blood-vessel lesion.

COMMENT

This case brings out certain points in the treatment of leaking aneurysm :—

1. It emphasizes the difficulties of operation during the fourth week after injury in the presence of wound sepsis and fibrosis.

2. It is essential to have transfusion with fresh blood available and to counterbalance blood-loss with blood replacement. The transfusion must be in the hands of a skilled resuscitation officer working in close co-operation with the anæsthetist.

3. A running record of pulse and blood-pressure must be maintained and readings are taken every five minutes at operation and quarter-hourly on return to bed. (To save space the chart, *Fig.* 338, only illustrates ten-minute intervals until return to bed and then four-hourly readings on the three immediate post-operative days.) It is only in this way that the resuscitation officer is able to regulate the transfusion accurately.

4. The dangers of secondary hæmorrhage following operation have been greatly lessened by penicillin.

5. No matter how apparently hopeless the outlook at operation may be, every effort should be made to complete the control of hæmorrhage and to treat the hæmorrhage and shock.

6. The amount of blood replacement was reasonably accurate, but it was not until twenty-two hours after operation that oxygen could be dispensed with, and control of the peripheral vasomotor mechanism was not re-established until the third post-operative day.

7. Operation must aim at controlling the proximal and distal artery and vein before approaching the site of the lesion. Because of fibrosis the proximal vein was difficult to isolate and was the cause of the trouble at operation.

It is no exaggeration to say that this case proves the old adage that while there is life there is hope. The credit for the successful outcome must be given in no small measure to the nursing skill and enthusiastic devotion of Sisters S. E. Wyvill and M. Thomas, to whom our grateful thanks are due.

We are indebted to Colonel L. J. Haydon, O.C. Hospital, for his permission to quote from the hospital records.

FULMINATING GAS GANGRENE INFECTION FOLLOWING AN ISCHIORECTAL ABSCESS

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FULMINATING gas gangrene infection following upon an ischiorectal or perirectal abscess is a rare condition, and few cases have been described.

The only strictly comparable case to the present one is that described by Berkow and Tolk (1923), which ended fatally, while the case described by Campbell (1929) seemed to be a much milder infection.

CASE REPORT

HISTORY.—The patient, E. C., a married woman aged 59, was admitted to the Cardiff Royal Infirmary on Sept. 19, 1944, at 8.0 p.m. Two days prior to admission the patient noticed a small swelling in the right buttock. This was not painful at first, but later it became tense and throbbing.

On the day before admission the right side of the vulva became swollen and the skin of the buttock and the right labium showed a brownish discoloration. The patient felt very tired and weak, and her appetite was poor.

On the day of admission the discoloration of the skin had become deeper in hue and had extended up the right labium on to the anterior abdominal wall. The patient felt fatigued and weaker and her general condition had gradually deteriorated. She had noticed that her urine was much darker than usual.

ON EXAMINATION.—The patient's general condition was poor, she looked toxic, and was obviously profoundly

ill. She had a dry furred tongue, a pulse of 140, of fairly good volume, and a temperature of 99°.

Locally there was a right-sided ischiorectal abscess 3 in. in diameter, which was fluctuant and tender. There was a marked dark-brown discoloration of the right buttock, the medial aspect of the right thigh, the right labium, and the anterior abdominal wall within 2 in. of the umbilicus (*Fig.* 339). The condition of the anterior abdominal wall resembled in its distribution the appearance sometimes seen with superficial extravasation

FIG. 339.—Colour photograph showing a right-sided ischiorectal abscess, with the typical discoloration of the skin, extending along the right labium and medial aspect of the right thigh.

of urine. An interesting fact was that the discoloration also extended up the right side of the vagina.

Crepitations could easily be felt and heard in the discoloured areas, especially in the right labium and in the right iliac fossa. The discoloured area had a fairly well-marked, raised edge and the whole area was painful and tender to touch. Rectal examination elicited marked tenderness on the right side overlying the abscess. On catheterization of the bladder 6 oz. of foul-smelling, dark urine were removed. It contained a trace of sugar, but no blood or ketones.

TREATMENT.—A pre-operative injection of morphine (gr. $\frac{1}{6}$) and atropine (gr. $\frac{1}{100}$) was given, and under general anæsthesia the ischiorectal abscess was opened by a cruciate incision. On opening the abscess the characteristic musty odour of the gas and blood-stained fluid was well marked. The necrotic tissue in the abscess cavity was black in colour, and this debris was evacuated. On exploration of the abscess cavity it was found that it extended up the right labium to the pubic region (*Figs.* 340, 341).

The cavity was packed with approximately 15 g. of sulphathiazole–proflavine powder (sulphathiazole 99 parts, proflavine 1 part) and vaseline gauze.

On return to the ward the patient's pulse was 120 per minute and of fair volume. Sulphadiazine tablets, 6 immediately and 3 four-hourly, were prescribed and 50,000 units of polyvalent antitoxin were given intravenously and repeated six-hourly. An intravenous glucose drip was set up. During the night her condition did not change appreciably. In the morning she was conscious and rational, but markedly apathetic. The area of discoloration was spreading and becoming much darker. Her temperature was now 97·5°, pulse 120 and of fair volume.

At 1.0 p.m. on Sept. 20 penicillin therapy was begun by the intramuscular route with the injection of 30,000 units; 15,000 units were then given three-hourly for four injections, making a total of 90,000 units.

The patient's general condition, however, gradually became worse and during the day she vomited several times. At 8.0 p.m. she became slightly irrational, the pulse was of poor volume with a rate of 150 per minute, and the temperature was 97·5°; 2 c.c. of anacardone (nikethamide) were now given by injection. Three hours later the pulse-rate was 180 per minute and hardly perceptible, and the temperature was 97·5°. The patient

FIG. 340.—Colour photograph showing the black necrotic debris after opening the abscess.

FIG. 341.—Colour photograph showing the extent of spread of the infection along the superficial tissue planes on to the anterior abdominal wall, resembling the picture sometimes seen with superficial extravasation of urine. The abscess cavity has been packed with sulphathiazole-proflavine powder.

became very irrational; her general condition rapidly deteriorated and she died at 2·30 a.m. on Sept. 21, thirty hours after admission.

Quantitatively, therapy had consisted of:—

a. 15 g. of sulphathiazole-proflavine powder locally.
b. 200,000 units of polyvalent antitoxin intravenously.
c. 90,000 units of penicillin intramuscularly.
d. 24 g. of sulphadiazine orally.
e. 2400 c.c. (approx.) of 5 per cent glucose solution intravenously.

POST-MORTEM EXAMINATION (P. M. 192/44).—Performed by Dr. J. Gough, on Sept. 21.

The body was that of a well-nourished middle-aged female. *Externally* there was a purplish discoloration of the skin of the right lower half of the abdomen and right flank, and upper part of the right thigh. There was no evidence of any other disease or injury.

There was an abscess in the right ischiorectal region. The whole region was black and gangrenous. The gangrene had extended along the right labium on to the abdominal wall in the subcutaneous tissues, in which

there was blackening of the tissues, which contained foul black fluid and gas.

Internally: The pharynx, œsophagus, stomach, and small intestine were normal. The rectum contained hæmorrhoids, but they were not inflamed. There was also one small uninfected anal fissure, but no fistula could be demonstrated between the ischiorectal abscess and the rectum.

The liver (1400 g.) was pale, but there was no gas formation in its substance. The cortex of the right kidney (150 g.) was pale. The surface was finely granular, and the capsule was somewhat adherent. The left kidney (150 g.) was similar to the right.

The heart (270 g.) was normal except for slight coronary atheroma. All other organs were normal.

BACTERIOLOGICAL REPORT (Dr. H. L. Carruthers).—Sept. 20 (24 hours before death).—Specimen, *Blood-clot.*—

Macroscopical examination of cooked-meat culture: Numerous Gram-positive cocci and bacilli with small numbers of bacilli having the morphology of *Cl. welchii* present.

The *Cl. welchii* was not grown on blood-agar anaerobically, but this, in my opinion, was a matter of a technical fault only.

Sept. 21. Specimen, *Swab* from P.M. 192/44.—

Direct examination of swab: Gram-positive cocci, bacilli, and numerous bacilli resembling *Cl. welchii*.

Aerobic culture: *Staph. aureus*, *Staph. fæcalis* in small numbers, with a good growth of a non-hæmolytic streptococcus.

No further anaerobic culture was made in view of the presence of *Cl. welchii* in the fist specimen.

COMMENTARY

The case described is an example of the acute fulminating type of gas gangrene infection, following upon an ischiorectal abscess. The literature shows that such an association of conditions is comparatively rare, and only two similar cases could be found.

The first case was described by Berkow and Tolk in 1923. Their patient, a man aged 54 years, was admitted to hospital complaining of pain and swelling in the region of the anus and scrotum of six days' duration. There was nothing of note in his previous history.

There was a large, red, indurated area in the ischiorectal region, extending to the left buttock, and a provisional diagnosis of ischiorectal and periurethral abscess was made. The day following admission, using ethyl chloride locally, multiple incisions and drainage of the ischiorectal region and scrotum were performed. The scrotum was enormously swollen and bluish in parts; when incised, dark blood, gas bubbles, and foul odour were noted. Later the incisions were flushed with hydrogen peroxide. Four hours after the operation skin crepitation was present just above the pubis, and the skin was becoming red and very tender. Five hours later the skin was indurated and crepitant.

Next morning the patient complained of great pain in the lower abdomen, and crepitation and induration were present to about 4 in. above the symphysis pubis. On the following day the patient was irrational, the crepitation increased, pulmonary œdema developed, and death occurred 79 hours after admission.

The temperature on admission was 99° F.: 36 hours later it rose to 101·2° F. and then fell to 98° F. The pulse varied from 100–128 per minute. Smears showed a profusion of short rather thick Gram-positive bacilli, and subcultures produced gas, but there was no further differentiation as to type.

Post-mortem examination revealed marked local and general changes, but no fistula was found between the ischiorectal abscess and the rectum.

Their case, however, did not receive any antitoxin.

The only other case of gas gangrene infection of this region that Berkow and Tolk could find in the literature was that described in 1919 by Thibault and Schulmann of gangrene of the scrotum from anaerobic infection, but later in 1929 Campbell described a case of "perirectal abscess due to gas bacillus".

His patient was a woman aged 34 years, who gave a two-day history and had an immense boggy swelling posterior to the anus and extending entirely across the buttocks with a gangrenous spot about three inches to the right of the anus. On the way to hospital the gangrenous spot ruptured, emitting a large amount of foul smelling pus and gas bubbles, The abscess area was crepitant, and the 48-hour culture grew the *B. welchii*.

Using ethyl chloride locally the abscess was then laid wide open, and three days after admission, as soon as it could be obtained, 40 c.c. of *perfringens* antitoxin was administered intravenously. The patient's condition changed dramatically, and eleven days after admission she left hospital, with an anal fistula, which was excised two months later, followed by complete recovery.

The route of infection in such cases as these is of interest, and Greeley (1918), writing on "Idiopathic *Bacillus aerogenes capsulatus* Infection", notes that "as the organism is a recognized common inhabitant of the intestinal tract and of distinct pathogenic abilities, it would be expected that lesions of the abdominal organs would not infrequently be followed by inflammation directly caused by this bacillus".

In view of these facts, Berkow and Tolk assumed that the route of the ischiorectal infection was through the gastro-intestinal tract, by way of a fistula communicating with the ischiorectal region. But in their case, and in the one now reported, a macroscopic fistula could not be demonstrated.

The seriousness of gas gangrene of the buttock has been stressed recently. Macfarlane (1943) pointed out that "patients in whom the gas gangrene involved the thigh or buttock region showed a poorer response to treatment than those in whom the lower leg or arm was affected. This was thought to be due to the difficulty of controlling the infection in a region with a relatively poor collateral circulation and in which surgical elimination of the infection might be difficult or impossible".

MacLennan (1944), writing on "Anaerobic Infections in Tripolitania", stated that "gas gangrene of the buttock is especially dangerous", and reported 2 cases, both ending fatally.

Macfarlane (1945), in a later communication, when dealing with cases of gas gangrene of the buttock, thigh, and shoulder, noted that "the death-rate in this type of case was absolutely much higher than in the cases with gas gangrene of the

leg or arm ", and that " in spite of the best treatment which could be given in these circumstances the death-rate from gas gangrene in these sites remains about 45 per cent ".

Such a severe case as the one described, with marked toxæmia, calls for intensive treatment, and all available methods of therapy must be employed.

MacLennan notes that accurate diagnosis is most important. In the present case, however, diagnosis was easy; therapy was the main problem.

Most authorities agree upon the urgency of appropriate surgical treatment, but as has been pointed out previously, this is more satisfactory in gas gangrene of the limbs than in infection of the trunk, especially of the buttock region. The most that can be done in the buttock region is to open up the infected area adequately, perform as thorough a surgical toilet as possible, and then apply an efficient wound antiseptic. For this purpose McIntosh and Selbie (1944) suggested a powder consisting of 1 part proflavine and 99 parts sulphathiazole, and in the present case 15 g. of this powder were introduced into the abscess cavity.

They also reported favourable experimental results (1943, 1942) with sulphadiazine, followed later by Hac and her associates (1943); 26 g. of this drug were given orally.

One of the most important features of the present case was the marked toxæmia, even after intensive therapy. Florey and Cairns (1943) observed that even when good surgery was combined with the use of so efficient a bacteriostatic agent as penicillin and the spread of infection had been arrested, the patient might still die of toxæmia.

A recent leader in *The Lancet* (1944) pointed out that " even when excision has removed the main source of the infection, toxin production may continue in small inaccessible remnants of necrotic tissue. It is the toxæmia that kills; antitoxin in adequate amounts is essential . . .".

The use of antitoxin in prevention and treatment of gas gangrene has been fully stated, and in the case now reported doses of 50,000 units 6-hourly were prescribed, with a total of 200,000 units.

Many have written on the use of penicillin in gas gangrene infections, including Jeffrey and Thomson (1944), who were convinced of its value in checking the spread of the infection, although clinical improvement was not obvious until 36 hours after commencement of penicillin therapy. This is of importance in the present case when it is considered that the patient died 13½ hours after penicillin therapy was begun.

Despite all this intensive treatment the patient died 30½ hours after admission to hospital with only a two-day history. This case admirably illustrates the truism, " it is the toxæmia that kills ".

My thanks are due to Mr. J. Berry Haycraft for allowing me to treat the case and to publish this account; to Dr. Jethro Gough for the post-mortem notes; to Dr. H. L. Carruthers for the bacteriological report; and to Dr. L. P. Thomas for the colour photographs.

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VOLVULUS OF THE CÆCUM: REPORT OF A CASE

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Volvulus of the cæcum was first described by Rokitansky in 1841. The condition is considered to be rare, Miller (1940) finding only 1 case out of 136 cases of acute intestinal obstruction in the Mayo Clinic, and Rothman et al. (1943) noting 1 case out of 150 cases of obstruction at the Harlem Hospital. The condition appears to be commoner outside the English-speaking countries, and certain European writers, especially Du Roux (1912) and Gatellier et al. (1931), have pointed out that the lesion is found oftener in Russia, Poland, Finland, and Scandinavia. Wolfer et al. (1942) believe that more than 300 cases had been recorded up till the time of their publication.

The condition appears to depend for its causation primarily upon excessive mobility of the ascending colon and terminal ileum, and thus to a failure in the fusing of mesenteries in the third stage of intestinal rotation. It is interesting to note that although, as Bryant (1921) pointed out, this latter anomaly is much commoner in the female, volvulus of the cæcum is three times commoner in the male subject.

Many different exciting causes have been given, such as over-exertion, violent peristalsis from over-eating or heavy purgation, and pregnancy. A few cases appear to have been associated with pregnancy, and Drayer (1911) described the mechanism by which the pregnant uterus displaced and twisted the mobile cæcum.

There are varying degrees of the process depending upon the mobility of the right colon and grading from the condition where there is a common ileocolic mesentery so that the colon may turn upon the superior mesenteric vessels as an axis, to the one where the isolated cæcum may turn upon itself in its cul-de-sac so that obstruction of the bowel is not caused. In the average case the cæcum with a few inches of the lowest ileum and the proximal ascending colon are the parts involved.

In most of the cases described the rotation of the bowel has been in a clockwise direction. This is not surprising as it is obviously much easier for the mobile ascending colon with its medial mesentery to roll in a clockwise direction towards the centre of the abdomen than to attempt to roll laterally beneath its own mesentery. Rothman et al. (1943) point out that the degree of torsion must be at least 180° upon its mesenteric border, as pathological changes do not occur before then.

The treatment of the lesion must be prompt because of the rapid distension of the cæcum and the imminent danger of rupture of its thin wall. The mortality of the recorded cases is over 50 per cent. In Valentine and Kinnear's case (1937) death occurred within five hours of the onset.

CASE REPORT

HISTORY.—M. B., aged 42, a bricklayer, was admitted to hospital with a history of acute abdominal pain and vomiting of eight hours' duration. The pain had come on at 3 a.m. while the patient was asleep in bed and had awakened him suddenly with its intensity. It was

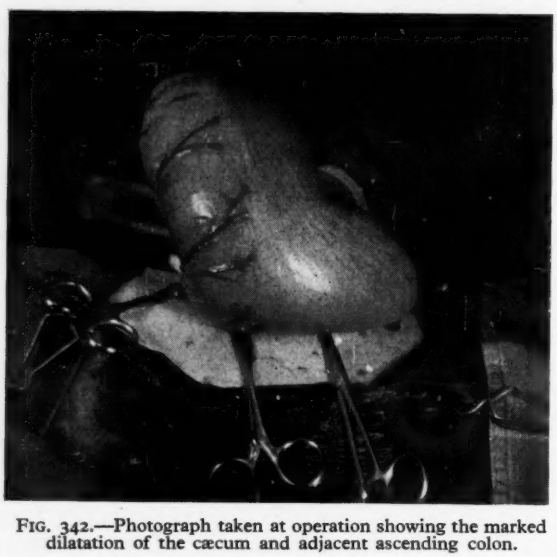

FIG. 342.—Photograph taken at operation showing the marked dilatation of the cæcum and adjacent ascending colon.

first felt in the upper abdomen, but after an hour or two had tended to settle in the right iliac fossa. Three hours after the onset vomiting commenced and continued to occur every half hour or so until admission, dark-green material being brought up on each occasion. The pain slowly increased in intensity and was constantly present, although the patient admitted that there were exacerbations of a more acute stabbing pain. Nine months previously he had had a similar attack of pain, but on that occasion it had been much less severe and had disappeared spontaneously after two hours.

ON EXAMINATION.—Physical examination disclosed a rather unhealthy, sallow male subject. The abdomen showed a slight generalized distension. In the right iliac fossa there was a prominent bulge which was exquisitely tender and tympanitic on percussion. The pulse on admission was 84 per minute and the temperature 98·4° F. The bowel moved soon after admission, the stool being fairly scanty but normal in appearance. The condition was diagnosed as volvulus of the cæcum and operation carried out half an hour after admission.

AT OPERATION.—The abdomen was opened by a right paramedial incision under ether anæsthesia. The distended cæcum at once bulged from the wound and there appeared to be a marked danger of it rupturing. The wound was enlarged and the distended loop delivered (*Fig.* 342). The cæcum with the lowest ileum and adjacent ascending colon had undergone torsion in a clockwise direction and had rotated through 540°, i.e., one-and-a-half circumferences. It was gently untwisted and some of the gas forced into the ascending and transverse colon. The appendix was then removed and the purse-string sutured to the peritoneum at the lower end of the wound to prevent any recurrence of the condition. The abdomen was then closed in layers without drainage.

PROGRESS.—Apart from a slight tendency to post-operative distension for a few days, the patient made an uninterrupted recovery, the temperature remaining normal and the pulse never rising above 84. He has remained well since the operation, now six months ago.

COMMENT

Examination at the time of operation showed that the cæcum and lower ascending colon were very mobile, but that the colon became abruptly firmly fixed to the posterior abdominal wall at a point slightly above the middle of the ascending colon, and it was at this point that the torsion had occurred. General hyperfixation of the colon will, of course, preclude any possibility of cæcal volvulus, but, as Carslaw (1928) pointed out, hyperfixation is often localized and is found particularly in the right colon. It will be appreciated that a point of hyperfixation in the ascending colon associated with looseness of the proximal part, such as was present in our case, provides a perfect combination conducing to volvulus, the mobile cæcum rotating round the fixed point, which acts as a hub. There was no apparent exciting cause present in our case.

The history of a similar attack of pain which subsided spontaneously is interesting and might be accepted as an argument for some form of fixation operation in those cases of mobile cæcum which form such a large proportion of the "chronic appendicitis" clinic.

In the treatment of the condition it seemed to us sufficient to attach the cæcum to the anterior abdominal wall at the operation wound.

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CHYLOTHORAX FOLLOWING TRAUMATIC PSEUDOCYST OF THE PANCREAS

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CASE REPORT

An able seaman, aged 23, was in hospital from May 3, 1944, till Feb. 26, 1945, following a kick in the epigastrium. During that time he developed a pancreatic cyst, bile peritonitis, chylothorax, and chylous ascites.

The sequence of events was as follows :—

May 3, 1944 : Admitted to Astley Ainslie Institution about two weeks after injury. He was kicked in the epigastrium at football, and continued to play for a few minutes, but then collapsed. He was in bed for a week and then sent on leave, still with persistent pain in the back. The day before admission he also had pain in the centre of the abdomen and right shoulder, with anorexia but no nausea or vomiting. He stated that his urine had been dark since the accident, and his bowels regular.

He was a pale slight man, not acutely ill. T. 97·4° ; P. 80 ; R. 20. Beyond some tenderness in the epigastrium and right hypochondrium, no abnormality was found. The urine was normal.

May 12 : Severe pain in the back and nausea. Very tender in epigastrium and right renal angle posteriorly. The stomach was dilated with wind, which was relieved with aq. menth. pip.

May 15 : A second attack as above, with also abdominal distension. This was relieved partly by a flatus enema and partly by gastric aspiration. The icteric index was 6.

May 25 : A third attack. Gross gastric dilatation, the percussion note being tympanitic nearly up to the left axilla and the apex beat displaced to the right. Continuous gastric suction brought some relief, but the abdomen remained distended, this time with fluid.

May 31 : 22 oz. of fluid withdrawn from the abdomen. It was sterile and contained blood and bile.

June 2 : 136 oz. fluid withdrawn in eighteen hours.

The abdomen was tapped another four times at weekly intervals, 6 oz., 84 oz., 40 oz., and 50 oz. of fluid being withdrawn. It contained bile in diminishing amounts and was always sterile. The patient was very miserable, was losing weight, and would not eat. He slept badly and complained of pain in the right hypochondrium.

June 27 : First Operation (Brigadier Anderson). Much turbid fluid was found in the abdomen. The bowel was distended and covered with fibrin flakes. No liver or gall-bladder injury was seen. The lesser sac was occupied by a pseudocyst of the pancreas, which was drained. The peritoneum was drained through a suprapubic stab wound.

After operation the patient was very ill. Plasma and later saline were given intravenously, and continuous gastric suction applied. After two days these were stopped. Both tubes drained profusely. The suprapubic drain was removed after four days. The drainage from the pancreatic cyst began to macerate the skin, so continuous suction was applied to the tube. Upwards of a pint was removed daily for a week. The diastatic index of this fluid was over 500 units/c.c.

July 11 : Tube removed. Some discharge continued for two weeks, and the wound was healed by the middle of August. The patient was now better, but very thin. His appetite was poor and he slept badly. He was apathetic and still had pain in the right hypochondrium and shoulder. A barium series was normal. Cholecystography showed no gall-bladder shadow.

Aug. 27 : Left-sided pleural effusion discovered.

Aug. 30 : One pint of milky fluid aspirated from chest. It was sterile and contained chyle. Aspiration was repeated seven times at about 10-day intervals ; from 6 oz. to a pint was removed at a time. Chyle was always present in diminishing amounts, and it was sterile.

In the middle of September he was less well, with an evening temperature up to 100° F., and he still had pain in the right hypochondrium. The laparotomy scar broke down and discharged pus for three weeks.

Sept. 30 : Gas found below the diaphragm by radiography.

Oct. 3 : Second Operation (Brigadier Anderson). Resection of end of 12th rib. No pus found, but granulation tissue in the subphrenic space. A large rubber tube was sutured into the wound,

Oct. 5 : Profuse sero-purulent discharge from the tube. Culture—scanty *Staph. aureus* and *Str. hæmolyticus.*

The tube was removed after nineteen days, after which the wound healed slowly. For three days he had diarrhœa and tenesmus, with tenderness in the pouch of Douglas. This subsided without treatment.

Oct. 17 : Abdominal distension noted.

Oct. 23 : 1½ pints of sterile chylous fluid withdrawn by abdominal paracentesis. General condition poor ; very pale and thin. Hb 67 per cent. Serum proteins 3·5 per cent.

Oct. 25 : Blood transfusion—one pint of fresh blood, followed by two-thirds of a pint of reconstituted dried plasma ; stopped because of a slight rigor. High protein diet ordered and amino-acid digest by mouth.

Oct. 26 : Profuse discharge of thick bile from anterior abdominal wound. The discharge required four changes of dressing in the day and ceased abruptly after two days. The wound healed and remained so except for a superficial abscess, which was opened on Nov. 22 and healed in a week. The general condition now began to improve, he ate enormously and put on weight, and became cheerful and interested. The abdomen was tapped a further four times up to Dec. 1, after which it ceased to fill up. From 2 to 4 pints of fluid were withdrawn on each occasion—milky-white fluid, containing chyle and always sterile. The fat content was 1·44 per cent and protein 1·5 per cent. Cells scanty, no admixture of pancreatic fluid. He developed a small right-sided pleural effusion which was tapped once, clear, sterile, serous fluid being withdrawn.

Jan. 28, 1945 : Devloped a bad cold in the head, with frontal sinusitis and small patch of consolidation at base of right lung. He made a good recovery with sulphadiazine (26 g. in 5 days). Other treatment given was a course of exercises and massage for the feet and legs, and ultra-violet light.

By the end of February he was up for most of the day, looking healthy, and with no abnormal physical signs apart from some pleural thickening at the right base, and muscle weakness consequent upon his long stay in bed.

Feb. 26 : Discharged to naval hospital for convalescence and final disposal.

Other investigations that were carried out showed no abnormality of the urine at any time, apart from a

trace of albumin the day after his blood transfusion, and no increase in the fat content of the stool.

DISCUSSION

The original injury sustained as a result of the kick seems to have been to the pancreas, leading to effusion of pancreatic fluid into the lesser sac and formation of a pseudocyst. This pseudocyst gradually increased in size, and was probably partly responsible for the large peritoneal effusion by pressure on the inferior vena cava. In addition, there must have been some injury to the biliary apparatus, though this was not obvious at operation, to account for the considerable quantities of bile found in the fluid. This bile caused an aseptic peritonitis, which increased the effusion and accounted for the obvious inflammation found at operation. On account of the inflammation and fibrinous exudate it was not possible to see the bile-ducts, but it is thought that there must have been a small tear either at the neck of the gall-bladder or in the cystic duct. This is borne out by the fact that: (*a*) There was no jaundice, therefore no obstruction of the common bile-duct; (*b*) The stools always contained bile-pigments; and (*c*) A cholecystogram showed a non-functioning gall-bladder. The biliary fistula which developed six months later was probably the escape of a collection of bile which had been localized in that area by adhesions resulting from the operation and the presence of a drainage tube. What is more difficult to account for is the chylothorax and subsequent chylous ascites. There was no chyle in the peritoneal effusion in the first series of tappings, therefore the escape of chyle was a late development and not part of the original injury. Why it should have appeared first in the left pleural cavity and afterwards in the peritoneum is a mystery. Draining the peritoneum had no effect on the pleural effusion.

The mortality of a traumatic (as distinct from a malignant) chylothorax is given as 75 per cent, and it is a wonder to all who saw this patient at his very ill stage that he made such a remarkable recovery.

I wish to thank Brigadier Anderson and Lieut.-Col. Cunningham, Medical Superintendent of the Astley Ainslie Institution, for permission and encouragement to publish this case.

REVIEWS AND NOTICES OF BOOKS

Proceedings of the Congress of C.M.F. Army Surgeons, Rome, February, 1945.

THE campaign in Italy, partly because of accidents of time and circumstance, but largely because of the ability and energy of the men who formed the medical services and the men who directed them, has been the most fruitful university for the study and advancement of military surgery in the history of the war. In Italy the surgeons from Middle East, First Army, and the American Forces first met. In Italy the lessons of a mobile desert campaign and of more static warfare among the mountain passes of Algeria were blended and subjected to the scrutiny of a band of enthusiasts fresh from civil surgery and centres of research. In Italy penicillin was first tried on a useful scale, and two-stage wound closure was developed as a planned policy. Here, too, the medical services were for the first time well supplied and well protected, and were able to evolve the methods that later proved their soundness in the final campaign in north-west Europe. This experience was discussed freely and frankly at a five-day conference held in Rome in February, 1945. The papers which were read at that congress, and the discussions which followed them, in which many visitors from other theatres of war took part, are reported in this volume.

The papers on the first day were devoted almost entirely to the treatment of wounds of the limbs, with special emphasis on the factors which had been found important in the primary and secondary operations of two-stage closure, and in the closure of compound fractures. Each speaker discussed some aspect of the problem on which he was particularly qualified to give an opinion, and the papers as a whole form a comprehensive account of this most important aspect of war surgery. The last contribution in the afternoon session, by Captain G. Parish, summarized the results of wound closure after the Gothic line battle; in 2693 cases operated upon there were only 9 per cent failures among compound fractures and 6 per cent among flesh wounds.

On the morning of the second day the delegates to the congress were received in audience by his Holiness the Pope. At the afternoon session, devoted to thoracic surgery, papers were read by Lt.-Col. d'Abreu, Major Nicholson, Captain Hodgkins, N.Z.M.C., and Major Maxwell Telling. These papers are among the most valuable in the proceedings, recording as they do the transition from the conservative attitude of the first world war and the earlier stages of this one, to the more radical outlook of to-day.

The subject of abdominal trauma was discussed on the third morning, and in the afternoon a clinical meeting was held at No. 10 Convalescent Depot. The marked improvement in the results of the surgery of abdominal wounds that is obvious in all published figures is due in the main to accessory methods such as transfusion, gastric suction, and venoclysis. One new principle, that of the exteriorization of colon wounds, has appeared, and Major Estcourt, reviewing the treatment of wounds of the large intestine, endorses this policy, but makes the plea that small wounds, particularly those of the right colon, should be treated by suture and drainage. In summing up Brigadier Edwards voiced the opinion of most experienced consultants in pleading that the policy of exteriorization should not be lightly discarded.

The papers on the fourth and fifth days are too important, and cover too wide a range of subjects, for any brief summarization. Injuries of the urethra, vascular injuries, burns, protein metabolism, resuscitation, cranial and facio-maxillary surgery, were all dealt with. Mention may be made of two papers on protein metabolism by American surgeons, Captain Somers H. Sturgis and Lt.-Col. Harwell Wilson, followed by one on the same subject by Major R. S. Garden, R.A.M.C. The three papers form an excellent summary of present knowledge on this very important subject, and are followed by a short but useful list of references. A short paper by Major P. Clarkson and T. H. H. Wilson and Captain R. S. Lawrie on the treatment of 100 jaw wounds

summarizes an experience in this particular aspect of war surgery that is probably unique.

This publication, which appears to be the work of the British Military Printing Press, is excellently and clearly produced on good paper and illustrated by six charts, one of them in six colours. It is probably the most valuable contribution on war surgery that has ever appeared. To future students of the surgery of the world conflict that has just ended it will form a more fruitful source of information than any official history is ever likely to be.

The Medical Annual, 1945. A Year Book of Treatment and Practitioner's Index. (Sixty-third Year.) Edited by Sir HENRY TIDY, K.B.E., M.A., M.D. (Oxon.), F.R.C.P., and A. RENDLE SHORT, M.D., B.S., B.Sc., F.R.C.S. $8\frac{1}{4} \times 5\frac{1}{2}$ in. Pp. 410 + ix, with 47 plates and 61 illustrations in text. 1945. Bristol: John Wright & Sons Ltd. 25s. net.

A REPATRIATED medical officer who had been a prisoner of war in Japan for nearly four years asked where he could find concise yet reliable information on some of the war-time advances in medicine and surgery; he mentioned penicillin and thiouracil as examples. What better volume than *The Medical Annual* could one recommend? Here he will find an excellent account of both, as well as summaries of the world's literature on other recent developments. They are not too short nor too long, and are authoritative and well documented for those who wish for more detailed information on any subject. The production and illustrations are excellent.

Duodenal and Jejunal Peptic Ulcer. By RUDOLF NISSEN, M.D., Attending Surgeon, Jewish Hospital of Brooklyn; formerly Professor of Surgery and Head of Department of Surgery, University of Istanbul, and Associate Professor of Surgery, University of Berlin. With a Foreword by Professor OWEN H. WANGENSTEEN. $8\frac{1}{2} \times 5\frac{5}{8}$ in. Pp. 143, with 123 illustrations. 1945. William Heinemann (Medical Books) Ltd. 21s. net.

THIS book is devoted to the procedures and recent advances in the surgery of peptic ulcer. It is well illustrated and contains some useful, practical points regarding technique.

The Treatment of Peptic Ulcer. Based upon Ten Years' Experience at the New York Hospital. By GEORGE J. HEUER, M.D., Professor of Surgery of Cornell University Medical College; Surgeon-in-Chief of the New York Hospital; assisted by CRANSTON HOLMAN, M.D., and WILLIAM A. COOPER, M.D., Assistant Professors of Clinical Surgery, Cornell University Medical College. 9 × $5\frac{7}{8}$ in. Pp. 118 + xii. 1945. Philadelphia and London: J. B. Lippincott Co. 18s.

THIS small monograph of just over a hundred pages presents a detailed study of some 1139 case histories of patients suffering from peptic ulcer. It consists of a 10-year clinical study in which 98·2 per cent of the patients were followed up and the various forms of treatment assessed.

This comprehensive survey of such a large number of cases is interesting and uncommon, and every surgeon who is interested in gastric surgery should study this monograph.

It is interesting to read that the authors do not find that extensive gastric resections produce better results than smaller resections, although the reduction in acid is greater.

In estimating the results of gastro-enterostomy and gastric resection, it has repeatedly been claimed that the great virtue of resection is that it protects the patient against recurrent ulceration and, therefore, against marginal ulcer, hæmorrhage, and perforation. The authors agree with this experience, but consider that this protection is relative and not absolute.

This monograph will form a useful book of reference.

Bone-grafting in the Treatment of Fractures. By J. R. ARMSTRONG, M.D., M.Ch., F.R.C.S., A/W/Comm. R.A.F.M.S., and Surgeon-in-Charge of an R.A.F. Orthopædic and Fracture Centre; Registrar to the Orthopædic Department and to the Fracture Clinic, Charing Cross Hospital, London; Registrar to the Metropolitan Hospital, London. With a Foreword by R. WATSON-JONES, B.Sc., M.Ch.Orth., F.R.C.S., Civilian Consultant in Orthopædic Surgery of the R.A.F. $9\frac{5}{8} \times 6\frac{3}{4}$ in. Pp. 175 + xii, with 204 illustrations. 1944. Edinburgh: E. & S. Livingstone Ltd. 25s. net.

THIS book gives a thorough and detailed account of the technique of onlay grafting. The modifications necessary for each bone and the surgical approaches to it are carefully described. The treatment of the subject is severely practical—perhaps too exclusively so. In a book of this size it might have been an advantage to deal at greater length with the development of bone-grafting, and the discussion of the principles on which the practice depends might well have been expanded. In his concentration on the onlay graft the author is somewhat unjust in his estimation of other methods. For instance, he condemns out of hand the sliding inlay graft for the tibia in spite of the fact that it has the advantage of making unnecessary the borrowing of bone from the sound limb and that it is successfully employed by many surgeons. Further, for internal fixation in a recent fracture of the radius, he prefers to borrow bone from the tibia to using equally satisfactory and more readily available vitallium plate.

Since the book was written, the use of cancellous bone from the ilium, often in the form of chips, has been greatly extended and very good results have been obtained by this method. A second edition would no doubt be considerably modified by this experience.

The book is beautifully illustrated and produced on fine paper.

Urological Surgery. By AUSTIN INGRAM DODSON, M.D., F.A.C.S., Professor of Urology, Medical College of Virginia; etc. With contributions by seven authors. $9\frac{3}{8} \times 6\frac{3}{8}$ in. Pp. 768, with 576 illustrations. 1945. London: Henry Kimpton. 50s. net.

THE appearance of a new work covering an extensive subject and written by one author is something of an event, and although there are seven other contributors to this volume their share is only six chapters out of a total of forty-six; the main body comes from the pen of Dr. Dodson alone. His first intention was to write on Surgical Treatment, and although it was later decided to include some pathology and diagnosis the original idea pervades the book; there is little pathology but much treatment.

Some of the views are in divergence with those held on this side of the Atlantic. Radiation is claimed as the most popular method of treatment of bladder tumours, whilst carcinoma of the penis is said to be radio-resistant; the general impression here is the exact opposite. Other differences of opinion between British and American

schools of thought are also apparent, and the book is certainly more American than international, very few references other than from American literature being quoted. This is not to detract from its value as a practical guide to the surgical urologist; in it he will find detailed instructions for the performance of almost every operation in urology, including eleven methods of nephropexy!

Used as a reference book for the practising surgeon it is invaluable; it is well produced and profusely illustrated, and is a monument to the experience and industry of the author. It is also very good value for the money.

The Principles and Practice of Rectal Surgery. By WILLIAM B. GABRIEL, M.S. (Lond.), F.R.C.S. (Eng.), Surgeon to St. Mark's Hospital for Cancer, Fistula, and other Diseases of the Rectum; Surgeon to the Royal Northern Hospital. Third edition. 9¾ × 6 in. Pp. 432 + ix, with 11 coloured plates and 237 illustrations, some in colour. 1945. London: H. K. Lewis & Co. Ltd. 45s. net.

THIS new edition of this well-known work will be very welcome not only among those who are interested in this branch of surgery, but with surgeons generally. The second edition was reviewed in the BRITISH JOURNAL OF SURGERY in 1937, and the present issue reflects the very large experience which has been enjoyed by the author during the intervening eight years and gives a very thorough representation of contemporary rectal surgery at its best. The book has been thoroughly revised and without any great addition to its size has been improved in many ways, including the addition of several new illustrations and coloured plates. With scarcely any exception the illustrations are of a high order and the plates are successful reproductions of excellent pictures.

Two chapters have been added, one on proctitis and the other on carcinoma of the anus and anal canal. The teaching has the merit of a sound pathological background and reflects the high standard of the work which has for so long been carried out in the laboratories at St. Mark's Hospital under the supervision and stimulus of Dr. Clement Dukes. The operative procedures recommended are described with great care and detail, while many points which might otherwise be in doubt are elucidated by suitable diagrams. One of the very valuable parts of the book is the references to the after-histories of patients, which make a storehouse of valuable information. The impact of the war has not left this field of surgery untouched, and the section on gunshot injuries is timely. In many places there is evidence of the author's wide knowledge of the literature of his subject and there is also appropriate acknowledgment of the contributions of other workers in this field. This edition continues the high standard which was set when the book was first published and will do much to sustain the reputation of rectal surgery as carried out at St. Mark's and as reflected in the practice of British surgery in this field.

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.*]

A Textbook of Surgery. By JOHN HOMANS, M.D., Clinical Professor of Surgery, Emeritus. Compiled from Lectures and Other Writings of Members of the Surgical Department of the Harvard Medical School. Sixth edition. 9⅝ × 6⅝ in. Pp. 1278 + viii, with 530 illustrations. 1945. Springfield, Ill.: Charles C. Thomas. (London: Baillière, Tindall & Cox.) $8.00.

L'Urographie Intra-veineuse (U.I.V.). By BERNARD FEY and PIERRE TRUCHOT. 9⅞ × 6⅜ in. Pp. 213 + viii, with 242 illustrations. 1944. Paris: Masson et Cie. 320 fr.

The Training and Employment of Disabled Persons. A Preliminary Report. 9 × 6 in. Pp. 302 + vi. 1945. Montreal: International Labour Office. 6s.

Plaster of Paris Technique in the Treatment of Fractures and Other Injuries. By Lt.-Col. T. B. Quigley, *M.C.*, M.D. 9¼ × 6 in. Pp. 107 + xiv, with 103 illustrations. 1945. New York: The Macmillan Company. 18s. net.

Demonstrations of Operative Surgery for Nurses. By HAMILTON BAILEY, F.R.C.S., Surgeon, Royal Northern Hospital, London; etc. 8½ × 5½ in. Pp. 348 + viii, with 531 illustrations, some in colour. 1945. Edinburgh: E. & S. Livingstone. 21s. net.

Le Catgut: Les Ligatures et les Sutures chirurgicales à travers les Âges. By Dr. A. FANDRE. With a Preface by Professor LOUIS BRUNTZ, Nancy. 9½ × 6¼ in. Pp. 651 + viii, with 137 illustrations. 1944. Paris: Masson et Cie. No price stated.

Illustrations of Regional Anatomy. B. E. By JAMIESON, M.D., Senior Demonstrator and Lecturer-Emeritus, Anatomy Department, University, Edinburgh. Sixth edition. 7⅞ × 6 in. 320 plates. In seven sections or in one bound volume (75s. net). 1945. Edinburgh: E. & S. Livingstone.

An Introduction to Clinical Surgery. Surgical Wherefores and Therefores: A Reasoned Explanation of Surgical Note-taking. By CHARLES F. M. SAINT, C.B.E., M.D., M.S., F.R.C.S. (Eng.), F.R.A.C.S., Professor of Surgery, University of Cape Town. 8½ × 5½ in. Pp. 293 + viii. 1945. Cape Town: Published for the Post-Graduate Press by *The African Bookman*. 25s.

Facial Prosthesis. By ARTHUR H. BULBULIAN, M.S., D.D.S., F.A.C.D., Director, Museum of Hygiene and Medicine, The Mayo Foundation, Rochester, Minn. 9⅛ × 6 in. Pp. 241 + viii, with 202 illustrations. 1945. London and Philadelphia: W. B. Saunders Co. Ltd. 25s. net.

A Manual of Surgical Anatomy. Prepared under the auspices of the Committee on Surgery of the Division of Medical Sciences of the National Research Council, by TOM JONES, Professor of Medical and Dental Illustration and Head of Department of Illustration Studios, University of Illinois Medical School, and W. C. SHEPARD, Art Editor, W. B. Saunders Co. 10¾ × 8 in. Pp. 195 + xvi, with 267 illustrations, 153 in colour. 1945. London and Philadelphia: W. B. Saunders Co. Ltd. 25s. net.